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THE CONTRIBUTIONS OF COUNT RUMFORD AND MICHAEL FARADAY TO THE MODERN MUSEUM OF SCIENCE[1]

By Sir WILLIAM BRAGG

DIRECTOR OF THE ROYAL INSTITUTION AND OF THE FARADAY RESEARCH LABORATORY

I AM told that I must say something about the "Diary of Michael Faraday," a book which we treasure at the Royal Institution. I would like to say a word or two about that at first but, as a matter of fact, I hope you will allow me to use it rather as a text for a somewhat larger subject, that is, the work that you and we are jointly trying to do.

Faraday's diary is indeed a most interesting document. It is contained in seven or eight large volumes of manuscript which have never been published. It is a record of his doings day by day. All his experimental work was collected by him from time to time and students in electricity know these papers and books of his quite well. But the diary is something more—it is the record day by day of what he thought, what work he was doing. It is a very human, very interesting document. He almost talks to us as he sits by night recording what happened to him during the day. Sometimes there is delight at having achieved success in an experiment, and sometimes a little fit of depression, as when he says, "So after all, that which I thought was a new discovery was only an accident." Sometimes he deliberately writes out an ordered plan for his next work. He uses some such phrases as: "So, if this takes place, the consequences should be. . . . Then I must try. . . ."

I assure you it is a most interesting book, and I trust the Royal Institution will succeed in publishing part of it next year. And then I hope that you all

[1] Address given by Sir William Henry Bragg at a science luncheon given in his honor at the Hotel Astor on May 27, 1930, by the Museums of the Peaceful Arts, the American Institute and the New York Electrical Society.

will feel the same charm that we do who have read it. The work that Faraday did is important to us in many ways because it is part of a great movement that is now beginning to take shape in the world.

If you would see the very beginnings of this movement, you will have to go back 250 years or more, to the time when such societies as the Royal Society of London first began to draw people's attention to the wonders of the world about them.

The first fellows of the Royal Society in London were just like a lot of school boys. As you look over the early volumes of the Royal Society *Transactions,* what will delight you most is the curious jumble of things submitted. Here is a man who gathers information respecting the ventilation of mines in Belgium. On the next page you will find a paper describing an animal monstrosity, etc. That was the Science Museum in those days.

If you step forward one hundred years or rather more, you come to Benjamin Thompson. Benjamin Thompson was a man who taught school in Rumford, Massachusetts—that was why he afterward assumed the particular title "Count Rumford." You will remember that in the time of the troubles between the colonies and the mother country, Rumford espoused the cause of the latter and was obliged to leave America.

Rumford was a strange man who believed in his heart in benevolent despotism. He went to England first and made his name both as statesman and as scientist. He afterwards went to Bavaria and took service with the Elector. He quickly rose to a position of considerable distinction and felt he was possessed of so much power that he carried out a most remarkable feat. He cleared the town of Munich of its beggars. Europe was overrun at that time, and in Munich they were estimated to be five per cent. of the whole population. He bought a building outside of the city, furnished it and on January 1, 1790 (which was Beggars' Day), Thompson so arranged with police officials of the city that, as each beggar put out his hand for alms, he was kindly but firmly led away to the Town Hall. There he was told that at the new institution there was food for him and warmth and liberty to work if he wanted it. It is hard to believe that such arbitrary measures could be successful, but the fact remains that he made the institution remunerative and its inmates happy, if we may believe his biographer.[2] That was indeed benevolent despotism.

He had the first ideas of applying scientific results to the needs of every-day life and he wrote several pamphlets on the subject. There are copies of them in this country. These pamphlets deal with what a scientific museum should be, how it should be conducted, what should be in it, what might be expected of it. He was a master of detail, and when you read over what he says, you realize you could not have a better guide if you wanted to set up a museum. He said, for example, that qualified instructors should be present to explain the models, and that is recognized now as one of the important features of a modern institution.

In a famous museum in Munich, where Rumford did his work, this principle is carried out in detail, and in the Science Museum of London there are hundreds of operating exhibits and the staff members are recognized generally as men of authority in their respective fields.

No doubt this is perfectly right. It is absolutely necessary to conduct a museum in this way. It is the best way to catch the public eye. I remember when I was a professor in Adelaide, we were to receive a visit from a member of Parliament. In connection with drawing his interest to our work, I remember the advice given me by a shrewd friend, "Mind you have something that buzzes or goes around." As a matter of fact, people do like to see things move.

Every year for more than a century Christmas lectures for children have been given at the Royal Institution. I notice that boys and girls like best to see demonstrations of mechanical principles, to see things working. We are all children still, and we do enjoy a science museum where there are working models and demonstrations of them. I think that the technique of a science museum is being gradually evolved. The operating model alone will not suffice, but I do regard it as one of the most fundamental means of instruction that we have.

I take it you represent these societies which are so interested in popularizing natural phenomena. We are linked together in one great endeavor to make the presentation of knowledge understood by the people and useful to them. That is the elemental feature.

Benjamin Thompson had great schemes. To those schemes, as a matter of fact, I owe my position, because it was under his scheme that the Royal Institution was organized in 1799. He was perhaps ahead of his time in creating an institution of working exhibits for public education. There is still a room that is called the model room. He called together various workmen—a plumber, a carpenter, a tinsmith, etc. He brought his various friends together to help in forwarding this idea. There was hardly sufficient understanding as to what might be done, or perhaps it was too ambitious, but at all events the scheme fell to pieces and he went back to Bavaria, but others remained behind, changed its purpose and went ahead.

Rumford always had the idea that there should be lectures, and certainly lectures are a very valuable ad-

[2] Rumford's life is described by Ellis in a book written at the instance of the American Academy of Arts and Sciences in Boston.

junct. Also the Franklin Institute, to which the Royal Institution is akin, has made great progress in this direction. To some extent these lectures have filled up the gap which Rumford saw but which are still to be perfected by institutions such as mine and yours. In our way we have tried to do it by having every week a discourse by some one who has really done something. He may have discovered something in chemistry or physics or built some bridge or discovered some historical remains, but the point is, he must have done something, and he lectures on that subject to people who are all interested in the progress in science and discovery.

I can not do better than to quote the directions given to the lecturer: He must speak on his subject to people who are interested in other subjects. He must not use technical terms which are not readily understood by all. It is a sort of liaison: an attempt to bind all the sciences together. The lectures have been a success and here I want to go back to Faraday.

This beginning by Rumford became an institution where research was carried on. But in those days systematic research was entirely new, and it was Davy and Faraday, who succeeded him, who were largely responsible for showing what research was and how it should be conducted. In that way the Royal Institution in London came to do scientific work that has played a great part in the world.

I won't attempt to describe what Faraday did because the subject is too great. What Faraday did is the foundation of all modern industry. He discovered the principle upon which the law of electrical engineering is built. He discovered the laws connecting electrochemistry and electricity, etc. I will give you a curious instance of how science develops into something at which everybody wonders.

One Friday evening a famous scientist was to give a lecture before the society and that afternoon Faraday spent with him going over the experiments, but when the evening came, the scientist had lost heart and never appeared. What could Faraday do? He went into the lecture room and went over the experiments as well as he could. When he had finished he began to pour out some of the thoughts that had been in his mind and when he had finished with this the subject had almost grown as he spoke. Afterwards he wrote a little paper, "Thoughts on Ray Vibrations," and this paper was, in fact, the starting-point of certain of his own researches into the electromagnetic theory and the foundation of the electromagnetic work of Maxwell and from that came the work of Hertz and from that came the achievements of Marconi and the modern wireless telephone.

Faraday's work was extremely fundamental and his work meant so much because he saw that experiment could draw together all the physical forms of the world. There is a certain passage in his works where he speaks of electricity, voltaic and statie, gravity, heat, cohesion, magnetism, etc.—a whole list of different physical forces and of his hope of coupling them all together. In a way his life work might be looked upon as an attempt to link them all up, for he was convinced that they were connected, and I may prove and illustrate my point by citing the names you give certain fundamental discoveries.

Faraday was the first to discover the principle of electromagnetic induction. You talk now of the principles of electromagnetism. He saw the connection between magnetism and light. We talk of magneto-optics. He saw the connection between electricity and chemistry. We talk of electrochemistry. It was that unity in which he believed—the unity of all nature. He lifted science above that which Rumford and his previous workers had conceived.

As time grows and the horizon widens, we see that the first views of what science does are greater now. We are all committed to the attempt to try to bring it to the service of mankind. It is a great enterprise and we only see dimly now what can be done, but we do hope to do much. In the attempt to explore the wonders of the world, to add beauty where people did not see beauty before, we are doing something for the service of mankind.

Robert Bridges, in the last great work of his, has astonished us by its beauty and its greatness. If you read "The Testament of Beauty," you will find that he has expressed for us the beauty of science. He talks of the influence of dreadful war and he speaks of the time when science will have brought many together into peace through common understanding of the unity and beauty of the world. He speaks of the time when

> War faln from a trumpeting vainglory to a crying shame
> Stalks with blasting curse branded on its brow.

Now you see that what we are aiming at is such a development of science, such a development of the wonders of the world, that we may lose all animosities in thought and understanding. That we may see the knowledge of the world, and all that is in the world, is a great thing at which to aim. In science there is no religion, but it is the act of religion. If we are religious at all in the deepest sense, we must try to bring all the good we can into the world to the service of man, and that is the great work we are all permitted to do.

I feel very much honored that you allow me to come here to-day and speak on that service in which we all feel deeply.

SUGGESTIONS OF COUNT RUMFORD[3]

In the prospectus of the Royal Institution of Great Britain in 1800 occur in part the following statements of Count Rumford representing his ideas for the formation of a public institution for the diffusion of knowledge and for facilitating the introduction of useful mechanical inventions and for bettering the condition of the poor:

The completest working models or constructions of the full size will be provided and exhibited in different parts of this public repository, of all such new mechanical inventions as are applicable to the common purposes of life.

Every consideration unites in showing how highly important it must be to the progress of real improvements to have some general collection of useful mechanical contrivances, constructed on the most approved principles and kept constantly in actual use, to which application can be made as to a standard, in order to determine whether the failure of experiments be owing to errors in principle, or to the mistakes of workmen employed in the construction, or to those of the servants intrusted with the management of the machinery.

How useful, also, would such a repository be for furnishing models and for giving instruction to artificers who may be employed in imitating them!

When we read the proposals of Count Rumford as to the organization of the Royal Institution, we see that we can have hardly a better guide to-day for founding a museum of science and industry than his suggestions of one hundred and thirty years ago.

PROPOSALS, ETC.

The two great objects of the Institution being the speedy and general diffusion of the knowledge of all new and useful improvements, in whatever quarter of the world they may originate, and teaching the application of scientific discoveries to the improvement of arts and manufactures in this country, and to the increase of domestic comfort and convenience, these objects will constantly be had in view, not only in the arrangement and execution of the plan, but also in the future management, of the Institution.

As much care will be taken to confine the establishment within its proper limits as to place it on a solid foundation, and to render it an ornament to the capital and an honour to the British nation.

In the execution of the plan, it is proposed to proceed in the following manner:

A place having been fixed on by the managers for forming the Institution, spacious and airy rooms will be prepared for the reception and public exhibition of all such new and mechanical inventions and improvements as shall be thought worthy of the public notice, and more especially of all such contrivances as shall tend to increase the conveniences and comforts of life, to promote domestic economy, to improve taste, or to promote useful industry.

The most perfect models of the full size will be provided, and exhibited in different parts of this public repository, of all such new mechanical inventions and improvements as are applicable to the common purposes of life.

Under this head will be included:

Cottage Fire-places, and Kitchen Utensils for Cottagers.
A complete Kitchen for a Farm-house, with all the necessary Utensils.
A complete Kitchen, with Kitchen Utensils, for the family of a gentleman of fortune.
A complete Laundry for a gentleman's family, or for a public hospital, including Boilers, Washing-room, Ironing-room, Drying-room, etc.
Several of the most approved German, Swedish, and Russian Stoves, for heating rooms and passages.

In order that those who visit this establishment may be enabled to acquire more just ideas of these various and mechanical contrivances, and of the circumstances on which their *peculiar merit* principally depends, the machinery exhibited will, as far as it shall be possible, *be shown in action*, or in *actual use;* and with regard to many of the articles it is evident that this can be done without any difficulty, and with very little additional expense.

Open Chimney Fire-places on the most approved principles will be fitted up as models in the different rooms, and fires will be kept constantly burning in them during the cold season.
Ornamental as well as economical Grates, for Open Chimney Fire-places, will also be exhibited; as also
Ornamental Stoves, in the form of elegant Chimney-pieces, for halls, drawing rooms, eating-rooms, etc.

It is likewise proposed to exhibit *working models*, on a reduced scale, of that most curious and most useful machine, the steam-engine.

Of Brewers' Boilers, with improved Fire-places.
Of Distillers' Coppers, with improved Fire-places and improved Condensers.
Of large Boilers for the kitchens of hospitals, and of Ships' Coppers, with improved Fire-places.

Farther, it is proposed to exhibit, in the repository of the Institution:

Models of Ventilators for supplying rooms and ships with fresh air.
Models of Hot-houses, with such improvements as can be made in their construction.
Models of Lime-kilns, on various constructions.
Models of Boilers, Steam-boilers, etc., for preparing food for cattle that are stall-fed.
Models of Cottages on various constructions.
Spinning-wheels and Looms, on various constructions, for the use of the poor, and adapted to their circumstances, together with such other machinery as may be useful in giving them employment at home.
Models of all such new-invented Machines and Implements as bid fair to be of use in Husbandry.
Models of Bridges, on various constructions; together with *models of all such other machines and useful instruments as the managers of the institution shall deem worthy of the public notice*, and proper to be publicly exhibited in the repository of the Institution.

[3] Taken by F. C. Brown from Volume IV of "The Complete Works of Count Rumford," as published by the American Academy of Arts and Sciences in 1870–75.

It is proposed that each article exhibited should be accompanied with a detailed account or description of it, properly illustrated by correct drawings.

In order to carry into effect the second object of the Institution, namely, *teaching the application of science to the useful purposes of life*, a lecture-room will be fitted up for philosophical lectures and experiments; and a complete *laboratory and philosophical apparatus*, with the necessary instruments, will be provided for making *chemical* and other *philosophical experiments*.

In fitting up this lecture-room (which will never be used for any other purpose than for giving lectures in Natural Philosophy and Philosophical Chemistry), convenient places will be provided and reserved for the subscribers; and care will be taken to warm and light the room properly, and provide for a sufficient supply of fresh air, so as to render it comfortable and salubrious.

In engaging lecturers for the Institution, care will be taken by the managers to invite none but men of the first eminence in science to officiate in that most important and most distinguished situation; and no subjects will ever be permitted to be discussed at these lectures but such as are strictly scientifical, and immediately connected with that particular branch of science publicly announced as the subject of the lecture. The managers to be responsible for the strict observance of this regulation.

In case there should be places to spare in the lecture-room, persons not subscribers will, on the recommendation of a subscriber, and on paying a certain small sum to be determined by the managers, be permitted to attend the public lectures, or any one or more of them.

Among the various branches of science that will occasionally be made the subjects of these public lectures may be reckoned the following, viz. These lectures will treat:

Of Heat, and its application to the various purposes of life.
Of the combustion of Inflammable Bodies, and the relative quantities of Heat producible by the different substances used as fuel.
Of the Management of Fire and the Economy of Fuel.
Of the Principles of the Warmth of Clothing.
Of the Effects of Heat and of Cold, and of hot and of cold winds, on the human body, in sickness and in health.
Of the Effects of breathing vitiated and confined air.
Of the Means that may be used to render Dwelling-houses comfortable and salubrious.
Of the Methods of procuring and preserving Ice in Summer; and of the best principles for constructing Ice-houses.
Of the Means of Preserving Food in different seasons and in different climates.
Of the Means of cooling Liquors in hot weather, without the assistance of ice.
Of Vegetation, and of the specific nature of those effects that are produced by Manures; and of the Art of composing Manures, and adapting them to the different kinds of soil.
Of the Nature of those changes that are produced on substances used as food in the various processes of cookery.
Of the Nature of those changes which take place in the Digestion of Food.
Of the Chemical Principles of the process of Tanning Leather; and of the objects that must particularly be had in view in attempts to improve that most useful art.
Of the Chemical Principles of the art of making Soap; of the art of Bleaching; of the art of Dyeing; and in general of *all the mechanical arts*, as they apply to the various branches of manufacture.

BIOCHEMICAL RELATIVITY

By W. H. MANWARING, M.D.

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ABOUT twenty-five years ago there were introduced into certain fields of physical science radically new basic concepts, particularly in reference to atomic structure and radiant energy. Within one decade the general acceptance of these new hypotheses rendered obsolete a thousand previous conscientious researches. For two decades the new theories have been the accepted basis for a hundred hitherto impossible practical applications. To-day we are apparently at the beginning of a similar basic revolution in certain biological sciences, particularly in those fields of physiology and biochemistry bearing on the phenomena of infection and bodily resistance.

Within the last five years there have been introduced in America, Germany, Russia, France and Czecho-Slovakia radically new immunochemical hypotheses, which, if generally accepted, will render inconclusive half of forty years' accumulated immunological literature. The suggested theory of biochemistry relativity casts doubt on a hundred current therapies, challenges a score of physiological orthodoxies, suggests a new perspective in ecology and genetics, has invaded the field of educational psychology and has already led to at least one previous chemical impossibility.

I

The theory of biochemical relativity was developed to explain the origin and nature of "specific antibodies." Demonstration of the existence of highly specialized biochemical defenses in the bloods and tissue fluids of convalescent and artificially immunized animals dates from the closing decade of the nineteenth century. Serum transfer of acquired immunity, serological conviction for murder, test-tube determination of illegitimacy and cutaneous tests for hereditary idiosyncrasies are a few typical applica-

tions. Since the opening of the twentieth century, the basic problem of immunology has been the determination of the origin, nature and physiological rôle of these highly specialized, defensive serum components.

These specific antibodies have never been isolated in sufficient purity for even approximate chemical analysis. Some of them are known to be associated with the globulin fraction of an immune serum, but whether they themselves are globulins or are simpler chemical substances carried by globulins is still undetermined. No immunochemist to-day can say whether the specific antibody known as diphtheria antitoxin, for example, is monovalent, bivalent or polyvalent for diphtheria toxin, or whether or not it forms a dissociable or a non-dissociable compound with that toxin. Even the postulated therapeutic union of toxin and antitoxin to form an inert, non-toxic colloid is nothing more than a convenient therapeutic metaphor.

II

In developing our historic theories as to the origin and function of these serum defenses, immunologists were handicapped not only by this lack of knowledge as to their chemical nature, but by numerous archaic physiological beliefs.

Early pagan physiology assumed, for example, that ingested foods are ceremoniously baptized with gastric juice and by this baptism forcibly detotemized, compelled to renounce all allegiance to their plant or animal of origin and to swear fealty to human flesh. A thousand pagan therapies and pagan religious ceremonials were based on this gastric psychology. In completely detotemized state the ingested foods were assumed to be absorbed into loyal vassalage to the human soul. Mid-Victorian physiology did little more than translate this ancient pagan physiology into the nomenclature of material science. It assumed without adequate proof that under the influence of digestive enzymes ingested proteins, for example, are completely hydrolyzed or detotemized into non-specific or immunologically inert peptones and amino acids, no undigested protein being physiologically absorbed into the blood stream. For three decades no immunologist questioned the truth of this 100 per cent. perfect Mid-Victorian digestion.

Later immunologists, therefore, were surprised and humiliated by inadvertent evidence that this Mid-Victorian nutritional ideal is never realized, that almost any alien protein applied to any mucous surface is absorbed unchanged into the circulating blood at least in sufficient quantities to stimulate the formation of specific antibodies. A few milligrams of non-toxic bacterial protein, for example, dissolved in physiological salt solution and applied to the vaginal mucosa, cause specific bacterial agglutinins to appear in the circulation at the end of the usual latent or incubation period for agglutinin formation. Within twenty minutes after swallowing raw egg, undigested egg-white is carried to all parts of the body, in sufficient quantities to call forth allergic reactions in distant, locally hypersensitive organs and tissues.

What percentage of a protein meal is thus absorbed unchanged, how much is taken up after the first, second and third hydrolysis and what proportion is not absorbed till complete detotemization into peptones and amino acids no immunologist is prepared to say. Difficulty arises from the fact that gastric acidity alone is known to change protein specificity. Detection in the circulating blood may now require a new anti-serum or a new series of animal tests. With each subsequent hydrolysis one or more new specificities may develop.

III

Early pagan physiology pictured urine as a powerful spiritual force, anesthetizing, paralyzing and enslaving undesirable tissue aliens, casting them into outer darkness. A thousand pagan therapies and pagan religious ceremonials were based on this urinary psychology. Mid-Victorian physiology translated this ancient belief and extended it to include renal excretion of parenteral alien proteins. For three decades no immunologist questioned the existence of this alien-protein-excreting renal function.

Later immunology, therefore, was again surprised and chagrined by the realization that there is no convincing evidence that there is any such renal function. In the albuminaturia following excessive ingestion of raw egg, for example, normal serum albumins and serum globulins appear in the urine, usually without a detectable trace of egg-white. It is, of course, admitted that after massive doses of alien proteins, and particularly with toxic proteins, capillary and glomerular permeability are so increased as to cause mechanical leakage. But this is far from proof of a normal physiologic function.

IV

Medieval Christian physiology assumed that no non-lethal beastliness that escapes excommunication from the human body can resist transubstantiation in the presence of the divine spark vitalizing human blood. A thousand ancient therapies and religious ceremonials were based on this hemic psychology. Mid-Victorian physiology translated this ancient faith into the belief that any foreign protein retained in the animal body is completely hydrolyzed or digested by the living tissues.

For thirty years immunologists placed implicit

faith in this 100 per cent. autopurification. Judge our humiliation, then, when we began to realize that there is as yet no convincing evidence that an appreciable parenteral digestion of alien proteins takes place.

Horse proteins are relatively non-toxic for most experimental animals, a fact that has led to the selection of horses for the production of therapeutic antisera. Injected intravenously, in moderate doses, horse proteins are apparently retained quantitatively in the normal canine circulation for at least six days, as determined by quantitative tests with anti-horse rabbit precipitin. Nevertheless, by the end of four days nearly 90 per cent. of the retained horse protein is so completely denatured as no longer to act as foreign protein in canine tissue. By the end of six days, fully 95 per cent. is so denatured. Or translated into immunological terminology, the retained horse protein is no longer demonstrably antigenic for dogs, though still retaining part of its original antigenicity for other animal species.

By the end of fourteen days, 99 per cent. of the retained horse protein is so completely homologized with canine tissues that it can not be differentiated from certain normal canine proteins by routine precipitin tests. It can be so differentiated, however, by the recently introduced quantitative precipitin graphs. In this highly caninized state at least 25 per cent. of the injected horse protein is demonstrable in the canine circulation at the end of three months. Traces of homologized horse protein have been reported in human blood several years after administration of diphtheria antitoxin.

V

Our present knowledge of protein chemistry is too elementary to warrant attempted hypotheses as to the mechanism of this biochemical adaptation of alien proteins to host tissues. A few very suggestive facts have recently been determined. For example, test-tube conjugation of a single amino acid with a protein molecule may alter its immunological specificity. In other words, it now resembles a protein of another plant or animal species. Two optical isomers of the same amino acid confer different specificities.

Test-tube conjugation with a single lipoid or a single polysaccharide may have similar effects. Conjugation with the same amino acid, polysaccharide or other immunological determinant may render two unrelated proteins so nearly identical, at least in their dominant specificities, as to be indistinguishable by routine precipitin tests. Egg albumen, for example, conjugated with the characteristic polysaccharide recently isolated from the pneumococcus is a successful vaccine against pneumococcus infections in animals.

The adoption of an alien protein by host tissues, therefore, does not necessitate radical changes in internal protein structure. Superficial conjugation with a single host determinant may be all that is necessary. Or a superficial burying of a single alien determinant.

IV

Medieval Christian physiology assumed that as a result of the postulated 100 per cent. excommunication and transubstantiation of alien substances the human body is preserved in the 100 per cent. virginal biochemical purity of Adam. Mid-Victorian physiology endorsed this ancient idealism. For thirty years no immunologist questioned it. It became the basic axiom underlying all our historic immunologic theories.

Specific antibodies were, therefore, of necessity pictured as preexisting normal Adamic colloids, increased or specifically mobilized to overcome toxic or infectious agents. In other words, every specific antibody was pictured a preformed purposeful specific antidote against some human disease, an antidote breathed into the body of the first man or acquired by the postulated miracle of evolution.

During three decades a thousand logical and consistent therapies were developed from this basic faith, hundreds of them tentatively adopted by clinical research, fully 95 per cent. of them afterwards discarded as clinical disappointments.

Theoretical immunologists were soon convinced that there must be something radically wrong in their logic, but few of them dreamed that the error was not theirs, but in the basic Mid-Victorian religio-physiology in which they placed such implicit faith.

VII

Later immunologists have been forced to the reluctant conclusion that this faith is unfounded, that no man is 100 per cent. biochemically perfect. He is but an organized colony of dominant human colloids, biochemical echoes of ancient and medieval infections, ceremoniously adopted personal diseases and incompletely homologized undigested dinners. For the first time in history, therefore, it was conceivable that specific antibodies might not be hereditary specific antidotes, but might be retained modified alien entities or partially dehumanized human proteins—hybridization products between toxic or infectious agents and host tissues. This is the tentative basic hypothesis of the newer immunology.

Probably the most convincing evidence that there is at least an element of truth in this futuristic concept is obtained from the recent realization of a previous impossibility, successful test-tube syntheses of specific antibodies, by simulating the postulated biochemical hybridization in the test-tube. By incubating diph-

theria toxin with normal serum, for example, or with individual serum proteins, either alone or in the presence of commercial enzymes, at least four different specific diphtheria antitoxins have been reported within the last three years. One of these is already patented in Germany. By the same or similar technique scores of artificial specific precipitins for plant and animal proteins have also been prepared. Artificial specific agglutinins for pathogenic micro-organisms. At least one synthetic bacteriocidal antiserum.

VIII

Of course, there is as yet no proof that any of these synthetic antibodies are identical with the natural antibodies formed in the animal body during the process of immunization. But there is suggestive evidence that, in time, artificial antibodies even superior to those formed by nature may be synthesized in the chemical laboratory—another blow to Mid-Victorian idealism.

By incubating diphtheria toxin with certain normal serum proteins, for example, two different artificial diphtheria antitoxins have been reported. With other serum proteins, however, the same observers obtained, with the same technique, not the expected antitoxins, but new toxins of exalted virulence and altered specificity. There is convincing evidence that this supertoxin synthesis also takes place in the animal body. With a proper mixture of the antitoxin-synthesizing and supertoxin-forming proteins, the resulting synthetic product is physiologically and therapeutically inert. Artificial antisera superior to those formed during natural immunization might conceivably result from an initial removal of the toxin-augmenting factor from normal serum.

IX

The newer immunology is not merely concerned with protective antibodies, but is equally interested in possible applications of biochemical hybridization to pathogenic micro-organisms.

It has long been known that celloidin particles suspended in dilute protein solutions undergo changes in electropotential, presumably due to the mechanical formation of superficial or interface protein films. In the presence of alien proteins, bacteria undergo similar changes. The bacteria may even acquire a slight agglutinability with specific precipitins for the environmental proteins. That a more radical hybridization than the postulated mechanical formation of superficial proteins films is possible is shown by growing the same micro-organisms for several generations in dilute proteins. By the eighth to twelfth generation in 10 per cent. horse serum, for example, the mechanically acquired precipitin agglutinability of typhoid bacilli is increased twenty fold. At the same time the bacilli completely lose their initial susceptibility to agglutination with ordinary typhoid agglutinin.

Presumably similar hybrid specificity develops in the animal body—recently published experiences with the causative agent of a certain form of canine distemper, for example. This distemper is readily transferred to ferrets. A sublethal dose of the splenic pulp of an infected dog is a successful canine vaccine against this disease at present extensively used in England. Similarly, a sublethal dose of infected ferret pulp is a successful vaccine for ferrets. But neither of these pulps immunizes or appreciably immunizes the opposite animal species. Apparently the common causative agent is so altered, not only superficially but in internal protein specificity in the two animal species, as to become, for all practical purposes, two immunologically distinct viruses.

A hundred clinics and research laboratories are today inspired by the hope that by test-tube simulation of this postulated protein hybridization new successes may follow in the hitherto discouraging field of vaccine therapy and serum therapy.

The newer immunology introduces equal uncertainty into current theories of filterable viruses and bacteriophage. It suggests a hitherto unpostulated etiology for senility and other degenerative diseases. It tends to make logical numerous currently unacceptable heresies as to cancer, tissue transplantation and hereditary idiosyncrasy. Unfortunately, it also suggests a hundred hitherto unexploited quackeries.

X

In outlining the present trend in immunological research I have, of course, passed beyond the boundary line of adequately demonstrated fact into the uncharted field of the research pioneer. One new basic fact in this field may render illogical every alleged fact I have presented.

For example, let us suppose that some future Avery or Landsteiner proves that egg white owes its immunological character to some superficial fowl-determinant—a lipoid, polysaccharide or amino acid, for example. Let us suppose he proves that this dominant determinant is dissociated from the relatively inert colloid molecule in the gastrointestinal tract and is absorbed into the blood stream. Let us further supposed this absorbed determinant now conjugated with some normal serum protein. There might thus be synthesized in the blood stream an atypical human colloid which few immunologists could distinguish from egg white by routine serological tests. Every alleged fact herein reported regarding the apparent gastrointestinal absorption of undigested egg white becomes obsolete.

XI

To theoretical immunologists the present transitional stage is the most interesting period since Pasteur and equally pregnant with potential clinical victories. To applied immunology, however, it is a period of humiliation, loss of faith in the guiding axiom of our forefathers, a new faith not yet sufficiently grounded for clinical application. A chaos in certain immunological specialties, with few immunotherapeutists "certain in their own minds whether they should be enrolled in future medical archives as honest empiricists or as ignorant charlatans." It is little comfort for them to realize that the basic guilt is not theirs, but rests in the archaic physiology in which they placed such implicit faith.

Above all the present is the dawn of a new perspective in American philanthropy and in American research administration. During the last three decades these agencies have made lavish provision for what the coming generation will inevitably regard as superficial pseudoresearch in immunology, feverish clinical application of unproved physiological hunches. At the same time, they have made negligible provision for the basic theoretical work by which alone the truth or falsity of the accepted postulates might have been established. The recent quarter million dollar grant to an American medical school for basic theoretical research, with the specification that the grant must not be used for purely practical applications of present knowledge, heralds the dawn of a new efficiency in conventional medical research.

A NEW METHOD OF DEEP SEA OBSERVATION AT FIRST HAND

By Professor HENRY FAIRFIELD OSBORN
HONORARY PRESIDENT OF THE NEW YORK ZOOLOGICAL SOCIETY

IMMEDIATELY on the receipt of a cable announcing the first successful descent of the Barton bathysphere I cabled to Director Beebe for a brief official report to be published in SCIENCE.

This is the thirteenth expedition of the Department of Tropical Research of the New York Zoological Society under the direction of William Beebe. It is the fifth year of oceanographic research of this department, and the third season at the Bermuda Oceanographic Station at Nonsuch Island. In the year 1928 the twenty-five acre island of Nonsuch, formerly a health and quarantine station erected by the Bermuda government, was placed at the disposition of the Zoological Society for oceanographic research. The seasons of 1928 and 1929 were devoted to the study of both the shallow and deep water fauna.

The buildings at Nonsuch were "transformed . . . into a comfortable and efficient Marine Zoological Station. The two large buildings were practically new and in perfect condition. The three large rain water tanks were overflowing." The relations with the government were excellent. "We were given every assistance, even to having the wreck of a large tug raised in St. George's Harbor, towed across Castle Harbor and sunk near our landing-place, forming a perfect breakwater for protection in rough weather. We had an excellent outfit both for laboratory work, shallow water investigation, and deep-sea trawling. Our electric light plant furnished light for sixty-odd bulbs, a frigidaire, aquarium pumps, etc. A pumping engine at the landing-place furnished three hundred gallons of salt water an hour for our aquariums."

The regular staff under William Beebe included seven assistants and from time to time was aided by Dr. J. Newton Harvey, Dr. C. J. Fish, Dr. Henry P. Bigelow, Professor William K. Gregory and other visiting experts.

In the recent report of the Zoological Society it is stated: "We secured over two hundred species of shallow water fish, about two thirds of the entire fish fauna of Bermuda, and gathered much material for life histories. The midwater depths—an area which we found most difficult to study—yielded many strange organisms. The deep-sea fish were taken from a restricted locality, five miles off shore, eight miles in diameter, and one half mile to one mile below the surface. They were collected in the course of five hundred and twenty-eight hauls, and in abundance and specialization surpassed our utmost expectations."

SEASON OF 1930

Although the most modern trawling devices were used and diving methods at shallower depths were highly successful, for the two seasons past Director Beebe has felt it of great importance to be able to carry on observations at greater depths. Mr. Otis Barton and the director have been working for two years on various problems of deep sea diving, at first studying a cylinder but finally designing a sphere or diving tank, illustrations of which have already begun to appear in the scientific reports from the Station. Director Beebe's own report of June 21, 1930, is as follows:

Director William Beebe and Mr. Otis Barton have just completed a number of dives in a deep sea chamber or bathysphere in the open ocean to a depth far beyond where any scientific observations at first hand have ever been made. This bathysphere was designed for and financed by Mr. Barton, who in frequent consultation with Dr. Beebe, has worked on it for a year. The barge from which the dives were made was kept anchored off Nonsuch Island where the New York Zoological Society Oceanographic Expedition has its headquarters, and the descents were made in the open sea in connection with and within the limits of the area of intensive research which Director Beebe has carried on for two years past, 1928–1929.

The length of cable at the greater depths was checked and rechecked both by hydrographic meter-wheel and by measuring off and marking one hundred foot lengths of the cable, the difference between these methods being two feet in one thousand four hundred and twenty-six.

On June 6th a descent was made to 803 feet, and on June 11th to 1,426 feet, or beyond a quarter of a mile, with both Beebe and Barton in the bathysphere. The sphere is 57.3 inches in outside diameter, and 1½ inches thick, and at the greatest depth withstood a pressure of 652 pounds to the square inch, or a total of 3366.2 tons on the whole surface. The exact locality was 32° 16′ No. Lat., and 64° 39′ West Long., five miles south of Nonsuch Island, Bermuda.

Fifteen dives have been made altogether, three to a depth of 800 feet. At Mr. Barton's own wish he took charge of the telephone communication and the supervision of the vital instruments and chemicals, while Dr. Beebe carried on ocular and instrumental observation at the window and controlled the depths. The more unusual fish and the extreme spectroscopic readings were also observed and confirmed by Mr. Barton.

The two most surprising phenomena were, first, the abundance of life observed, and the clarity and certainty with which it could be seen and identified, and second, the blue brilliance of the watery light to the naked eye, long after every particle of color had been drained from the spectrum. Another unexpected fact was the presence of fish and invertebrates at these upper levels which, in trawling nets, have been taken only hundreds of fathoms lower. At 700 feet the spectrum, as seen close against the quartz window, was quite devoid of color, the lightest portion being at the 510th wave-length. The last color to disappear was violet, which, many feet above, had completely overlaid the blue.

The visual degeneration of the spectrum was read every fifty feet, and rechecked on different dives and by both divers, and the radical color alteration in known species of fish agreed with the shifting spectrum. An intensity meter was read in connection with the spectroscope.

A strong, electric search-light illuminated the outside water to a distance of many feet, a bag of decayed fish and baited hooks served as a lure, an outside thermometer was easily read, and perfect telephone communication and dictation were carried on without interruption.

Luminous fish and shrimp swam close to the quartz window, about a dozen species of true bathypelagic fish being identified and seen again and again. Among these were *Myctophum, Diaphus, Serrivomer, Idiacanthus, Stomias, Leptocephalus, Cyclothone* and *Argyropelecus*. Puzzling results of the trawling nets were explained, and every possible ecological fact noted and dictated.

A second very important phase of the work proved to be dangerous but exceedingly interesting. This was to lower the bathysphere in shallow water, and as the guiding vessel slowly drifted seaward, to do contour exploration down the Bermudian insular shelf. The risk was the possibility of suddenly sighting a wall of reef too near to be cleared by reeling the sphere quickly upward. Four such descents, to a maximum of 350 feet, yielded unexpected results, revealing an entirely new fish fauna at these offshore depths and opening an absolutely new future field, for the study of the unknown bottom life connecting the shore with the deep sea faunas. The most notable thing about the recognizable shore fish was their great average size.

The only dive when Beebe and Barton were not together in the bathysphere was Dive Number 8, when General Assistant John Tee-Van and the technical associate Gloria Hollister went down to 400 feet and made many interesting observations.

Great credit should be given to Assistants Tee-Van and Hollister for their days of recording work on the deck of the barge. Mr. Tee-Van had full charge of the deck crew and the hoisting machinery and carried on without accident or mistake. Miss Hollister received and correctly and instantly transmitted the scores of orders and observations, contending often with bad static and with confused, over-enthusiastic diction from a quarter of a mile beneath the surface.

The satisfactory margin of safety and the ease and accuracy of observations of fish and other bathypelagic organisms have ensured the advisability of the continued use of the bathysphere for another year.

NONSUCH ISLAND,
JUNE 21, 1930

SCIENTIFIC EVENTS

THE SCIENTIFIC LABORATORIES AND UNIVERSITY ASSISTANTS IN ITALY

PROFESSOR ERMANNO FIORETTI, in an address before the Italian Chamber of Deputies, has called attention, as reported by the correspondent of the *Journal* of the American Medical Association, to some problems of the Italian universities which are awaiting solution, namely, the mode of functioning of the scientific laboratories and the working conditions of the university assistants. The speaker emphasized that the university laboratories should receive larger appropriations, as at present they have not adequate resources for the researches that they are called on to conduct in the interest of scientific progress. Recently there was organized in Italy a campaign against experimental studies carried out on animals, and at a meeting in Rome of the Society for the Protection of Animals, which was attended by many Italian and foreign women, a protest against vivisection was launched. But, Professor Fioretti explained, experimental studies are the very basis of the progress of medical science and certain discoveries (for instance, that of Luciani on the function of the cerebellum) would not have been made without the aid of vivisection. It is necessary, however, that vivisection be well controlled and be carried out solely in authorized institutes. According to the speaker, reducing the number of Italian universities, as has been suggested in some quarters, should not be considered. That is the opinion held also by the head of the government. But there is need of distributing the various faculties in such a manner that there shall be fewer faculties of medicine but provided with greater resources than at present.

The university assistants, Professor Fioretti stated, have not only the duty of assisting in scientific researches and laboratory studies but also the complex task of directing the young students and starting them in their laboratory work. It is necessary, therefore, to consider their living conditions, in order to check the exodus of young men from the scientific institutes and the present scarcity of university assistants. In addition to giving them more pay there is need also of guaranteeing the stability of their career, which is at the mercy of the incumbent in the professorial chair, who may dismiss at his pleasure young men who have had years of experience as assistants. These conditions lower the scientific and didactic performance of the assistants, as is evident also from the results of the state examinations for admittance to the practice of medicine, which this year have shown thirty per cent. of failures. According to Professor Fioretti, the university career, which is long, should be shortened, so that there will be more chairs available for the young professors.

EXPEDITION OF THE DANA

THE *Dana* dropped anchor at Plymouth on June 22 on the conclusion of a two years' oceanographical cruise, which, according to a correspondent of the London *Times*, may prove to be the most important of its kind since *H.M.S. Challenger* returned from her famous quest in 1876. She had anchored at Plymouth on her outward journey precisely two years previously, on June 20, 1928.

The ship is the Royal Danish research ship *Dana*, purchased in 1921 and adapted by the Danish government for oceanographical research. She is "sister" to the *George Bligh* and the *Explorer*, research ships of the English Fisheries Department and the Fishery Board for Scotland, respectively. The cruise was not her first, nor is it likely to be her last, but it is improbable that, for some time to come, she will again undertake so long and extensive a voyage.

The leader of the expedition is Dr. Johannes Schmidt and the commander of the ship Captain G. Hansen. The expenses of the enterprise are shared between the Danish government and the Carlsberg Foundation, whose generosity to science is a household word in Denmark, and the expedition is under the direct patronage of Prince Valdemar of Denmark, the youngest brother of the late Queen Alexandra. The *Dana* left Copenhagen on June 14, 1928, and is expected to return to her home port in a few days, after calling, at the invitation of the Government of the French Republic, at Boulogne.

Although the route of the expedition was largely dictated by Dr. Schmidt's desire to study the eels, the main purpose of it was a general investigation of the oceans, and throughout the voyage the oceans have been studied from every point of view by means of the most up-to-date apparatus of marine research—apparatus undreamed of in the days of the *Challenger*. The *Dana* is equipped with echo-sounding gear, by means of which a large number of soundings have been taken; water samples have been taken at various depths from the surface to the bottom, and the temperature and chemical composition of the water at these depths observed and recorded. Collections have been made throughout of the abundant planktonic life of the sea and of the larger marine fauna, down to the greatest depths.

The full results of the expedition can not be known for years, because the mass of material collected will take years of work by many investigators to sort, identify and tabulate. In fact, it is only now, when this two years' cruise has reached an end, that reports are coming forward on the material collected in the cruise of the expeditions of 1920–22, by means

of which Dr. Schmidt established the facts of the life history of the Atlantic eels. There can be no doubt, however, that the voyage of 65,000 sea miles, from Copenhagen across the Atlantic, through the Panama Canal, to Tahiti, New Zealand and Australia, thence to the Dutch East Indies and China, across the Indian Ocean to East Africa, round the Cape and thence through the Straits of Gibraltar into the Mediterranean—where Dr. Schmidt was determined to check, by means of his most up-to-date apparatus, the findings of previous expeditions conducted by him in that sea—and finally back to her home port, will prove to have furnished contributions of the utmost importance in the science of the oceans.

THE SOLAR ECLIPSE EXPEDITION OF THE U. S. NAVAL OBSERVATORY

FURTHER details in regard to the expedition to observe the total eclipse of the sun on October 21 by the U. S. Naval Observatory have been given out by the Navy Department. The sun will enter the shadow at 9 o'clock in the morning, and be totally obscured for ninety-three seconds.

The expedition will leave Washington on July 19 and will sail from San Francisco on July 31 on the steamer *Sierra,* arriving at Tutuila, Samoa, on August 13. The following investigators will comprise the party:

Commander C. H. J. Keppler, in administrative charge; Commander Keppler headed the Navy's expedition which observed the solar eclipse of May 9, 1929, from the vicinity of Iloilo, Philippine Islands.

Lieutenant H. C. Kellers, Naval Medical Corps, who was a member of the naval eclipse expedition at Sumatra in 1926 and also of the 1929 expedition. Lieutenant Kellers will be medical officer and in charge of meteorological observations, and, at the request of the Smithsonian Institution, he will collect specimens of the island fauna and flora.

Professor S. A. Mitchell, director of the Leander McCormick Observatory at the University of Virginia, who will conduct spectrographic work.

Kempton Adams, assistant to Professor Mitchell.

Professor Ross W. Marriott, Swarthmore College astronomer, who will carry out coronal photography with a 63-foot camera and make observations to test the Einstein theory.

Dr. Weld Arnold, of the American Geographical Society, assistant to Professor Marriott.

J. J. Johnson, of the California Institute of Technology, who will make photometric observations.

B. P. Sharpless, junior astronomer at the Naval Observatory, who will do coronal photography with a 15-foot camera and other smaller ones.

Dr. T. A. Jaggar, Jr., of the Volcanic Observatory at Hawaii, who will study volcanic and seismic conditions on Niuafou Island.

In addition to this scientific personnel eleven enlisted men of the Navy and Marine Corps will go to assist in construction work and in taking observations. These men, selected from the personnel of the battle fleet, sailed from the Mare Island Navy Yard aboard the mine sweeper *Tanager* on June 25 and will arrive at Samoa about August 9. The enlisted personnel includes a rigger, an optical repair and instrument man, a carpenter to construct large cameras, an expert photographer, two general assistants, two radio operators, two cooks and an interpreter.

About 115 boxes and cases of scientific instruments and equipment have been shipped to Tutuila, besides camp equipage and food supplies sufficient for twenty men for sixty days, and about 8,000 board feet of lumber for the construction of various cameras. The largest of these cameras will have a focal length of sixty-five feet and include a photographic developing room.

Niuafou is a very small volcanic island about 300 miles west southwest of Tutuila. Primitive conditions prevail and only two white men and 1,100 natives live there.

About thirty craters are on the island. Many of them have recently been active, and a major eruption occurred in June, 1929, which destroyed one of the two villages. There are no good anchorages and only one precarious landing place.

THE LIFE SCIENCES BUILDING OF THE UNIVERSITY OF CALIFORNIA

THE work of moving thirteen departments from eleven wood-frame buildings into the new fireproof and earthquake proof Life Sciences Building at the University of California is practically completed. This building was the first to be built on the Berkeley campus under the provisions of the state bond issue of 1926, and cost $2,000,000.

The Life Sciences Building, said to be the largest academic building in America, is five stories in height, has a floor area of 321,000 square feet and provides 60 per cent. more space than the eleven buildings which it replaces, combined.

Among the old buildings which the completion and occupation of the Life Sciences Building will leave empty, are: Agricultural Chemistry, erected in 1908; Anatomy, erected originally as shops for the department of mining; Botany, erected in 1898; Budd Hall of Biochemistry, erected in 1896; California Museum of Vertebrate Zoology, a temporary structure of wood and corrugated iron which has been in service for twenty-one years; East Hall or Zoology Building, erected in 1898; Home Economics, a wooden building erected in 1916; Hygiene and Pathology, erected in 1913; Psychology Building, erected in 1898; Spreckels Physiology Laboratory, erected in 1903.

As soon as possible the work of tearing down the old buildings will be started and their sites will be landscaped or used for other purposes. The site of Budd Hall will be utilized for the Eshleman Memorial Building to house student publications. Aside from these eleven structures, other obsolete buildings which new construction is replacing are: the old student infirmary, replaced by the new $450,000 Cowell Memorial Hospital; the old power house, replaced by a new $400,000 heating plant capable of supplying the augmented needs of the campus.

The Life Sciences Building, in addition to its more than 400 laboratory and office rooms and the Museum of Vertebrate Zoology, has an auditorium seating 500, and a library with a capacity of 90,000 volumes.

HONORARY DEGREES FROM YALE UNIVERSITY

THE citations on the occasion of the conferring of honorary doctorates of science at the recent commencement of Yale University were as follows:

EDWIN GRANT CONKLIN, Sc.D.

Professor Phelps: Biologist. Bachelor of Science, Ohio Wesleyan University, 1885. B.A. 1886, M.A. 1889. Ph.D. Johns Hopkins, 1891, and recipient of many honorary degrees. Held the chair of biology at Ohio Wesleyan, and since then has been professor of zoology at Northwestern, University of Pennsylvania, and since 1908 at Princeton. He is a member of many learned societies in Europe and in America. His publications are numerous and important; including "Heredity and Environment," "Mechanism of Evolution," "Direction of Human Evolution," "Biology and Democracy" and other works on heredity and education. The range of his interest is as wide as life itself. He is a great scholar and a great citizen. His investigations have been largely in the fields of cytology, particularly cell division, and of embryology, both descriptive and experimental. In his work on the development of mollusks and ascidians he has followed closely the changes from the single-celled egg through all successive cell divisions, to the formation of the principal organs of the adult body. His work has all been done with great attention to detail, with extraordinary accuracy and with completeness. His papers have always been finished with artistic perfection. He has been willing to spend a fair portion of his time in making his science comprehensible to the general reader. In this he has been most successful, as his popularity as lecturer and author testify.

President Angell: Everywhere recognized as one of the distinguished biologists of your time, you possess two qualities rarely conjoined in eminent scientific men—a genius for sound and exhaustive work of the greatest precision, issuing in fruitful and striking discoveries, combined with a broad and profound outlook on the whole field of biological science, especially in its remoter human implications, about which you write so lucidly that even the interested layman may understand. In recognition of these remarkable gifts, Yale University is proud to confer upon you the degree of Doctor of Science, admitting you to all its rights and privileges.

CHARLES SCHUCHERT, Sc.D.

Professor Phelps: One of the most distinguished of the scientists of Yale, in the front rank of paleontologists, and the world's leading authority on paleo-climatology. A youth in Cincinnati, while belonging to the younger generation, he was paradoxically a collector of fossils. He taught paleontology in Kentucky, New York and Minnesota, coming to Yale in 1892. He has done work for the U. S. Geological Survey, for the U. S. National Museum, and in 1904 was appointed at Yale professor of paleontology and historical geology, becoming professor emeritus in 1923, since when he has, if possible, worked harder than ever. He may be seen at an early hour every morning entering the Peabody Museum. He is the author of a standard work, "Historical Geological Paleogeography of North America." His services to Yale University have been and are now invaluable. Although his professional interests are concerned with prehistoric time, he is held in the warmest affection by contemporary men; every one who knows him is his friend.

President Angell: You have long served Yale with fidelity and distinction. She has been proud of your leadership in the field of your special study, a leadership which no one challenges. In token of the high respect in which your scientific work is held and in affectionate remembrance of your long years of devoted service to her interests, Yale University gladly confers upon you the degree of Doctor of Science, admitting you to all its rights and privileges.

SCIENTIFIC NOTES AND NEWS

A TRIBUTE to President W. W. Campbell, who retired from office at the University of California on July 1, was paid by the regents at their last meeting. Prepared by Regent Chester A. Rowell, the following resolution of appreciation was adopted: "On the eve of the retirement of President William Wallace Campbell, after nearly forty years of distinguished service to the University of California, the regents hereby record their appreciation of a great scholar, an outstanding administrator and an inspiring character. After a long and notable career as astronomer and director of Lick Observatory, Dr. Campbell came to the presidency at a time of many and difficult problems. Already eminent in the world of intellect and of knowledge, his high ideals, fine spirit, clear vision, decisive judgment and administrative efficiency as an ex-

ecutive have left a permanent record of achievement in the progress of the institution over which he presides. In the midst of complex external problems and great material development, he has never lost sight of the main purposes of a university: the advancement of teaching and learning and the increase of usefulness to its students and to the state. With regret that the time of official retirement has arrived, and with the affectionate hope of many years of happiness and usefulness, the regents tender this tribute of acknowledgment."

Dr. Harvey Washington Wiley, from 1883 to 1912 chief chemist of the U. S. Department of Agriculture, died at Washington, D. C., on June 30, at the age of eighty-five years.

Dr. E. Starr Judd, of the Mayo Clinic, professor of surgery in the Graduate School of the University of Michigan, was elected president of the American Medical Association at the recent Detroit meeting.

Northwestern University has conferred the doctorate of science on Olin H. Basquin, Chicago engineer and one of the organizers of the School of Engineering at Northwestern University, and on Dr. G. Carl Huber, professor of anatomy and dean of the graduate school of the University of Michigan.

The University of Michigan has conferred on Mr. Frank Leverett, lately glacialist on the staff of the U. S. Geological Survey and staff lecturer on glacial geology at the university, the honorary degree of doctor of science.

Hamline University at its recent commencement conferred the degree of doctor of laws on Dr. Charles Horace Mayo, of the Mayo Foundation.

Dr. J. Trueman Thompson, professor of civil engineering at the Johns Hopkins University, has been appointed manager of the sixth International Road Congress. The congress, which it is expected will be attended by leading highway engineers, administrators and economists from virtually every civilized country in the world, will meet in Washington from October 6 to 11 at the invitation of the United States government.

Dr. Edwin O. Jordan, professor of bacteriology at the University of Chicago, has been elected a member of the board of scientific directors of the International Health Division of the Rockefeller Institute.

Colonel Harley B. Ferguson, Corps of Engineers, has been appointed a member of the Board of Engineers for Rivers and Harbors, to succeed Colonel George B. Pillsbury.

M. Ch. Fabry and M. Ch. Maurain have been elected to the council of the National Bureau of Scientific Research and Invention, Paris, in succession to the late M. Pateau and the late M. Sebert.

Dr. Marcus Benjamin, the editor of the publications of the United States National Museum, was one of the five recipients of the Medal of Service given for the first time at the recent commencement of Columbia University. The award was made in recognition of Dr. Benjamin's "long years of patient and effective work in his chosen field of endeavor."

Dr. Thurman D. Kitchin, dean of the Medical School of Wake Forest College for thirteen years, has been elected president of the college. He succeeds Dr. Francis P. Gaines, who resigned to become president of Washington and Lee University.

Lyman D. Phifer, associate in botany at the University of Washington, has been named assistant director for the spring of 1930–31 of the university's Oceanographic Laboratories in the upper Puget Sound. He will aid Dr. Thomas G. Thompson, recently appointed to direct the laboratories in the program of scientific research in oceanography which is being outlined. Dr. Thompson is now on an extended European tour studying oceanographic methods in the Mediterranean, Central Europe and North Atlantic laboratories. He holds a traveling fellowship granted him by the Rockefeller Foundation.

At a recent meeting of the board of regents, the appointment of a new executive committee to govern the University of Michigan Medical School was approved. The directorship of the division of preclinical medicine will go to Dr. Frederick G. Novy, head of the department of bacteriology and a member of the old executive committee. Graduate medicine will be under the supervision of Dr. James D. Bruce, present supervisor of the work. Clinical medicine will be directed by Dr. Udo J. Wile, of the department of dermatology and syphilology. Dr. Harley A. Haynes will have complete direction of the University Hospital and Dr. Arthur C. Curtis, former assistant to the dean of the medical school, now becomes secretary. Dr. Hugh Cabot is said to have resigned from his chair in the university.

Dr. Earl W. Phelan, of Western Reserve University, has been appointed professor of chemistry at the Georgia State Womans College, Valdosta, Georgia.

Dr. Walter R. Fieseler, formerly medical supervisor of athletics at the University of Iowa, has resigned from the faculty of the college of medicine to become associate medical director at the University of Southern California.

At the University of Cambridge there will be established for three years a temporary professorship of colloidal physics, which in the first instance is to be

held by Mr. E. K. Rideal, of Trinity Hall. The professorship is to be primarily assigned to the faculty of physics and chemistry.

AT the Paris Observatory, M. Fayet, director of the Nice Observatory, and M. Lambert, associate astronomer at Paris, have been appointed astronomers to succeed the late M. Fatou and M. Hamy, who recently retired.

DR. WILLIAM R. MAXON, associate curator of the division of plants of the U. S. National Museum, has sailed for Europe. As a representative of the Smithsonian Institution he will attend the International Botanical Congress to be held at Cambridge this summer. Part of his time will be spent at the British Museum (Natural History) and the Royal Botanic Gardens, Kew, where he will continue preparation of the fern volume for the Flora of Jamaica.

DR. WARREN D. SMITH is conducting a course in geography and geology of the Pacific Basin on the University of Oregon Summer School cruise to Hawaii from June 25 to August 1. During the fall quarter of 1930–31 he plans to visit the west coast of South America.

DR. GEORGE B. RAY, associate professor of physiology in the School of Medicine of Western Reserve University, sailed from New York on July 5 to spend the summer in Germany. From September to March, Dr. Ray will study with Dr. Joseph Barcroft, professor of physiology at the University of Cambridge.

DRS. W. A. ALBRECHT and Samuel Brody, associate professors, respectively, of soils and dairy chemistry at the University of Missouri, have been given a year's leave of absence to be spent in Europe.

A SPECIAL cable dispatch to the New York *Sun*, under date of July 3, reports that a storm in the Gobi Desert, which wrecked his camp and scattered his supplies on June 10, forced the return to Peiping of Roy Chapman Andrews to obtain supplies.

THE annual address before the Kentucky Chapter of Sigma Xi was delivered by Professor Leo E. Melchers, head of the department of botany of the Kansas State Agricultural College. The lecture was illustrated and entitled "Life and Scenes along the Nile." The speaker recently returned from Egypt where he had been making a study of Egyptian agriculture.

THE Huxley Memorial Lecture of the Imperial College of Science and Technology next year will be delivered by Sir A. Smith Woodward, on "Modern Progress in Vertebrate Paleontology."

THE ninety-eighth annual meeting of the British Medical Association will be held at Winnipeg from August 26 to 29.

As a result of the action taken at the first International Congress of Soil Science held in Washington in 1927, the second congress will be held in Russia from July 20 to 31. The first International Congress was held under the joint auspices of the U. S. Department of Agriculture and the American Society of Agronomy. Meetings for the first six days of this year's congress will be in Leningrad and the remaining time will be spent in Moscow. Following the congress, an excursion of 29 days will be made across the soil zones of European Russia, during which members of the congress will have an opportunity to study the soils and visit schools, agricultural experiment stations and farming and industrial enterprises.

THE Second International Pediatric Congress will meet in Stockholm, from August 18 to 21, under the presidency of Professor I. Jundell, of the University of Stockholm. Three main subjects will be considered: (1) The biological effect of direct and indirect ultra-violet irradiation, which will be reviewed by Dr. Hess of New York. (2) The physiological and pathological significance of the thymo-lymphatic system, reviewed by Dr. Hammar of Uppsala, Cattaneo of Milan, Moro of Heidelberg and Mouriquand of Lyons. (3) The psychology and pathology of childhood, reviewed by Gillespie of London, Hamburger of Graz, Krasnogorski of Leningrad and Péchère of Brussels. Other subject will be discussed in various section meetings.

UNDER the patronage of H. M. King Albert of Belgium, it is proposed to hold an International Congress of Historical Geography at Brussels, from August 11 to 14. It is possible, according to the *Scottish Geographical Magazine*, that a meeting may be arranged at Liége, and one at Antwerp, and the date of the congress will coincide with that of the International Exhibitions at Liége and Antwerp, and with the festivities organized in commemoration of the centenary of the independence of Belgium. The president of the congress is Professor H. Van der Linden, of the University of Liége, and the general secretary is Professor F. Quicke, of the Royal Athénée, Brussels. Communications should be sent to the latter at 3 Avenue Saint-Augustin, Forest-Brussels.

THE will of the late Colonel William Boyce Thompson leaves his collection of minerals and carved stones to the American Museum of Natural History, with the provision that the collection shall remain at his residence as long as his widow and daughter reside there, unless permission to remove it is given. The collection is to be designated by the museum as "the

Boyce Thompson mineral collection." The will provides a fund of $20,000 to the museum for preparation of a room or building to house the collection and another fund of $50,000 for the purchase of additions to the collection and for its maintenance. No further endowment is provided by the will for the Boyce Thompson Botanical Institute.

CONGRESS without a dissenting vote has passed the Smoot-Elliott bill authorizing an appropriation of $6,500,000 for the enlargement of the U. S. National Museum.

THE Research Institute of the Lankenau Hospital announces the opening of a Marine Experimental Station at North Truro, Cape Cod, Massachusetts, to extend the study of the chemistry of cell division to marine animals. This was made possible by a gift of land from the L. D. Baker estate and a building the gift of Mr. A. Bein, of Philadelphia.

CEREMONIES in connection with the laying of the cornerstone of the new engineering laboratory of the Westinghouse Electric Company built at a cost of $2,000,000 took place on June 10. As Mr. W. S. Rugg, vice-president of the company, placed the model cornerstone in position, delicate relays controlled by the "electric eye" operated the hoist that swung the actual cornerstone into place. The actual cornerstone, and a model on a crane at the right of Mr. Rugg, exactly followed his movements as he placed the model stone in place on the model building. The laboratory, which will be the largest and tallest arc-welded structure in the world, will contain twenty-five elaborately equipped laboratories for nearly every branch of the electrical industry.

THE *Journal* of the American Medical Association reports that the new School of Public Health and Tropical Medicine was opened in Sydney, on March 6. It will carry on the work of the School of Tropical Medicine, which has been in existence since 1907 at Townsville. It is housed in its own building within the grounds of the university, close to the medical school. Erected at a cost of £35,000, it provides for departments of parasitology, entomology, bacteriology, pathology and chemistry, while sections dealing with physiology, industrial hygiene, epidemiology, vital statistics and sanitary engineering are contemplated. It will be under the control of a council composed of representatives of the commonwealth government and the University of Sydney. Dr. Harvey Sutton has been appointed director. It will provide especially for the graduate training of public-health personnel, but will also include special non-medical courses of school hygiene in the diploma of education and of tropical hygiene in the diploma of anthropology. The courses for the diploma in public health and for the diploma in tropical medicine have already been commenced, and a diploma of tropical hygiene is contemplated. A library to deal with public health and tropical medicine is being built up from a nucleus, previously existing at Townsville, which, it is hoped, will be complete in all Australian aspects.

A NEW zoological institute and a combined physical and chemical institute will be erected at the University of Munich through funds given by the Rockefeller Foundation. The donation makes it possible to abandon a previous plan to provide for the two departments of the university by making additions to the Wilhelminum, the renaissance palace in the Neuhauserstrasse. This plan is said to have met with opposition from Munich artists and friends of art.

THE Chemical Foundation, Inc., has made a gift of $100,000 to the recently created National Institute of Public Health.

THE Rockefeller Foundation has informed the senate of the University of Sydney that it will contribute £100,000 to provide laboratory facilities for the departments of surgery, pathology, bacteriology and allied subjects.

THE acquisition by Columbia University of a Weights and Measures Library containing works from 1520 to the present time and forming what is said to be the most comprehensive collection of volumes on the science of weights and measures in the possession of any educational institution has been announced. The collection is the gift of Samuel S. Dale, of Boston, formerly editor of the *Textile World Record*, an authority on weights and measures, in memory of his father and mother, Thomas and Fanny Dale, of Little Falls, N. Y. The works number between 1,100 and 1,200 volumes, with some 700 pamphlets.

WE learn from *Nature* that the question of the destiny of the Radcliffe Observatory site and buildings has now come officially before the University of Oxford in the form of a decree in congregation. By this it is proposed to accept the offer of Sir William Morris, the purchaser of the site from the Radcliffe trustees, to vest the whole of the property in the hands of a body of trustees, in order that it may be used for the benefit of the Radcliffe Infirmary and the Medical School of the university. The terms of the trust provide that the old observatory building shall be used for the purpose of medical teaching and research, and that the observer's house and garden shall be used as a residence for the director of the institute of research to be constituted.

CONSTRUCTION of an observatory to house a 5-inch equatorial telescope, recently secured by the Panama Canal from the United States Navy, is in progress. The building is being erected on a small hill a short distance to the northwest of the Miraflores filtration plant, and will be a circular structure 14 feet in diameter, with 6-inch concrete wall. It will be topped with a mobile steel dome equipped to travel on a circular track, permitting the use of the telescope toward all points of the compass and facilitating the observation of celestial bodies in all parts of the heavens. The observatory is being established through the efforts of the Canal Zone Astronomical Society, with the assistance of the canal administration, and is to be used for the instruction of students of the Canal Zone high schools and for Panama Canal employees interested in or associated with astronomical societies. Ground was broken for the building on April 11, and it was expected that the work would be completed in June. The position of the center point of the pier on which the telescope will rest is: Latitude 9° 00′ 15″ North; longitude, 79° 35′ 51″ West.

THE European producers of mercury, desiring new uses for the metal, have offered a prize under the following stipulations: (1) A prize will be awarded, under the conditions below, to whoever proves to a commission of the European producers to have found a new use for mercury or its salts, and to have industrially exploited it, the extent of the use being defined as in (3) below. (2) The use should be as yet unknown to the industry, and should be regularly and definitely protected by patent not before January 1, 1930, in Germany and the United States. (3) The application must be important enough to indicate a new consumption of mercury of at least 1,000 flasks during 1930, 3,000 in 1934 and 5,000 in 1935. (4) The prize will be awarded by a commission consisting of the president and vice-president of the European producers and two technicians named by the Spanish Academy of Sciences and the Academy of Italy, or their representatives. The prize will be £5,000 sterling, £1,000 to be paid immediately upon the decision of the commission; £2,000 one year after the condition in (3) above has been confirmed, and £2,000 two years after the condition in (3) has been confirmed and the consumption of the metal estimated practically and confirmed by the commission. (5) The commission may delay the award, reduce its value or prolong the period of offer without giving any reason for its action. (6) The decision of the commission is final without notification of reasons. (7) The complete account of the studies and practical experiments relating to the new application should be presented in quadruplicate, printed or typewritten either in Spanish, Italian, German, English or French, and should be sent, registered, to Mercurio Europeo, Bureau de Repartition, Plaza St., Francois 5, Lausanne, from which further information may be obtained.

TWELVE National Radium Centers have been nominated by the British Radium Commission, as being places where there are medical schools with complete clinical courses and where treatment of patients can be combined with the education in approved methods of radium therapy. The centers are: *England*—Birmingham, Bristol, Leeds, Liverpool, Manchester, Newcastle and Sheffield; *Scotland*—Aberdeen, Dundee, Edinburgh and Glasgow; *Wales*—Cardiff. Loans of radium are being restricted in each area to one hospital selected by the medical faculty of the local university. London has been treated as a separate and special problem, and steps have been taken to organize two centers to carry out special work of general and national importance. Approximately 17 grams of radium out of a possible total of about 22 have been ordered and provisionally allocated by the commission to national centers. Of this quantity, nine grams have already been received from the manufacturers, and, after being tested at the National Physical Laboratory, 6¼ have been delivered to centers and a further 3½ will be going out very shortly. In collaboration with the Medical Research Council and the British Empire Cancer Campaign, a set of "Radium National Forms" for the use of recognized centers has been prepared, in order that the clinical records of all cases treated may be kept on a uniform basis and eventually incorporated in general national statistics.

DISCUSSION

SEA-LEVEL CHANGE NEAR NEW YORK

UNDER the above title Professors A. C. Lane and W. F. Cheney, Jr., in the March 21 issue of SCIENCE call attention to what they term "an erroneous statement" in *Bulletin* of the National Research Council Number 70 entitled "Studies of Mean Sea-level." The wording of their criticism might lead the reader to infer an error in computation which affected the validity of a certain conclusion set forth in that bulletin, namely, that tidal observations at Fort Hamilton, New York, indicate no appreciable change in sea-level during the last thirty-five years. Those familiar with the bulletin in question will appreciate that Lane and Cheney disagree rather with the conclusion itself. Accepting the figures given there, they proceed to deduce mathematically a probable rise of sea-level of 0.0047 feet a year $\pm$ 0.06, or as they otherwise state it, a probable rise of about 0.6 feet

per century. This they consider an "appreciable" change. The comments of Lane and Cheney are pertinent from two points of view.

In the first place, the wording of the bulletin while correct is not as precise as it should be, since it is open to the interpretation that the studies there described do definitely indicate some progressive change in mean sea-level, but that the author of the bulletin did not consider such change appreciable. The text of the bulletin should have stated more clearly that the tidal observations give absolutely no proof of any progressive change whatever in the relative levels of land and sea in the last thirty-five years; and further, that if any slight change has occurred it must have been inappreciable, since it is so effectively masked by much larger temporary irregular and periodic changes in sea-level (due to meteorological and other causes) as to be incapable of demonstration.

In the second place, it is of course pertinent to challenge the fundamental conclusion itself, as correctly worded in the foregoing sentence. This Lane and Cheney have in effect done. The reader should remember that both in the communication of these authors and in the text to which they refer, the expression "appreciable change in sea-level" is really a short-cut for the phrase "progressive, cumulative change in sea-level continuing over a significant period of time and measurable in terms of inches or feet per century." This is clear from the context in both cases; and indeed the existence or non-existence of such a progressive change is the only point at issue. All agree that there are short-time fluctuations of sea-level, both irregular and periodic, which render difficult the determination of slow progressive changes of level in a given direction for long periods of time.

With the mathematical calculations of Lane and Cheney the present writer would find no fault, but he can not accept their conclusion that the figures indicate a progressive rise of sea-level. It was clearly foreseen that the tidal data set forth in the bulletin were mathematically capable of interpretation as an indication of rising sea-level, and both this fact and the objections to such an interpretation were set forth with some fulness. On this point the present writer can not do better than quote extracts from pages 37 and 38 of the document[1] in question, retaining reference to figures and tables in the bulletin for sake of clarity in the text as quoted:

> Casual inspection of the curve showing the average mean sea-level for each year of this period might lead one to conclude that there has been a progressive rise of mean sea-level or a progressive subsidence of the land at this point. Thus the yearly mean sea-level repeatedly sank below the datum plane to which these readings are referred (supposed mean sea-level at Sandy Hook) during the years 1893–1913; but it has never fallen that low since 1913. Again, as shown in Table 9, the average position of mean sea-level for the first five years of this period is lower than for any subsequent five-year period.
>
> But the curve shown in Fig. 14 and the data tabulated in Table 9 must be interpreted in the light of our present knowledge of the marked fluctuations to which mean sea-level is subject owing to astronomical, meteorological and other conditions. The curve itself is sufficient evidence that mean sea-level varies greatly from year to year, and indicates that these variations are apparently highly irregular and unsystematic. The work of W. Bell Dawson and H. A. Marmer has shown that there are periodic variations in mean sea-level, and that if we average the records for a number of years so as to eliminate the discordant effects of great annual variations, there will appear some evidence of a four-year period, and also of a nine-year period. Thus the average position of sea-level at a given point during one complete four-year period may differ from that of another four-year period by as much as two inches, even when no real change in the general elevation of land or sea is taking place. Similarly the nine-year period may cause fictitious appearance of progressive emergence or submergence amounting to an inch or more. When we have available accurate tidal records extending over very long stretches of time, we may discover that there are other and longer periodic fluctuations of sea-level due to astronomical and meteorological causes.
>
> When we examine the curve of Fig. 14 and the data tabulated in Table 9, with the known fluctuations of mean sea-level in mind, we see that they afford no proof of any progressive change in the general level of land or sea. The annual variations, the four-year variations and the nine-year variations shown by the curve are all within the limits of variations normally due to astronomical and meteorological causes. The more or less steady rise of sea-level from 1912 to 1919 was followed by a more or less steady fall from 1919 to 1926. As shown in Table 9, the average position of mean sea-level for the first five years of the thirty-year period 1898–1927 differed from that of the last five years by only 0.01 foot, or little more than one tenth of an inch. Obviously, there is nothing thus far revealed in the Fort Hamilton record which can be taken to indicate a progressive rise of the general sea-level, or a progressive subsidence of the land.

One need only add that in 1925 Marmer wrote: "It may therefore well be that the apparent subsidence of the coast from 1909 to 1919 represents but the rising phase of a fluctuation in sea-level with a period of something like twenty years."[2] The drop

[1] Douglas Johnson, "Studies of Mean Sea-level," *Bull. Nat. Res. Council* No. 70, 50 pp., 1929.

[2] H. A. Marmer, "Sea-level Along the Atlantic Coast of the United States and its Fluctuations," *Geogr. Review*, 15: 438–448, 1925. See p. 447.

of sea-level from 1919 to 1926 referred to above may afford some support for Marmer's twenty-year period, a support not necessarily negatived by the higher level of 1927. Time will give the answer to this phase of the problem, as to others.

Should continued tidal observations at Fort Hamilton demonstrate the reality of a very slow rise of sea-level, thus far masked by the combination of irregular and periodic variations of the ocean surface, we would still be far from the demonstration of a general progressive rise of sea-level or subsidence of the land. Such rise might be but the upward swing of a periodic fluctuation extending over a span of time longer than any yet determined. Accurate tidal records do not go far enough back to enable us to detect a thirty-five-year or longer period. Again, the rise might be both local and temporary, due to changes in the form of shores and channels, as set forth on page 39 of the bulletin previously cited. Comparison with other tidal stations would in time reveal the nature of the rise.

Meanwhile we must recognize the following pertinent facts. (*a*) Although mean sea-level is the best known datum from which to reckon slow progressive changes in the relative levels of land and sea, it is itself an uneven surface. Furthermore, it is an extremely sensitive surface, subject to both irregular and periodic changes in altitude some of which extend over decades. (*b*) Hence the determination of slow progressive mean sea-level changes, far from being the simple operation it was once considered, is a peculiarly delicate and difficult task. (*c*) While precise tidal observations are now available for a period sufficiently long to show the absence, during such period, of any pronounced rate of subsidence, like the one or two feet per century commonly attributed to the Atlantic Coast, the occurrence of a much slower change (what the writer has called an "inappreciable" change) can be neither affirmed nor denied until many more years of precise tidal observations are at our disposal. The writer does not deny the possibility of a slight or slow change, and hopes some one may take sufficient interest in the subject to finance the maintenance of a tidal station in some position suitable for the required critical observations.

With the suggestion of Lane and Cheney that the whole question deserves further consideration we are in hearty accord. Aside from its scientific interest the problem of slow sea-level changes enters into practical affairs where the engineer must foresee increased wave activity on a subsiding coast, where title to submerged property depends on whether the submergence was due to natural or artificial causes and in other circumstances which need not be considered here. Hence every contribution to this difficult problem is doubly welcome. But it is not clear that the further suggestion relating to meanders in streams flowing at and below tide-level is pertinent to the question at issue. Even if such meanders indicate past submergence (which remains to be demonstrated), it is difficult to see how they could throw any light on slow changes in sea-level supposed to be taking place at the present time.

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ON GENUS AND SPECIES MAKING

PROFESSOR NEEDHAM'S objections to certain lengthy generic names[1] appears to have brought forth a flood of comment, mostly reactionary, not only concerning the length of generic names but also relative to the alleged overmultiplication of generic names.[2] More recently Dr. Hubbs[3] has hastened to the defense of the systematic zoologist. As a systematic zoologist working with the invertebrates I venture to offer a few comments, not only in the matter of generic names, but also in the treatment of specific variation. For the past hundred or more years the work of defining new genera has been in progress. At first these groups were founded upon characters contained only in the external parts of the animals, principally the shells of mollusks and other invertebrates. As the internal organs began to receive attention, new characters or combinations of characters were discovered which resulted in further splitting of older names, and in advancing subgenera to generic rank. Any one who has followed the development of the classification of the land Pulmonata under the epoch-making studies of Dr. Pilsbry, in which many new genera and higher groups have been diagnosed, can not but admit that the subject has been made clearer by the addition of the many generic groups.

This division into genera is a refinement of classification made necessary by our advance in knowledge of the structure of animal life. After all, classification is only for the interpretation of natural laws, including the separation of the various types of animal life into groups for purposes of use in different lines of investigation, and for this purpose nothing has been suggested that is in any manner an improvement over the modified Linnaean system now in use. Degrees of differentiation are well indicated by classes, orders, families and genera. Suggestions have been made from time to time that numbers or symbols would be an improvement, but every systematist knows full well that such systems would be totally out of the question for practical use.

[1] SCIENCE, 71: 26–28, 1930.
[2] SCIENCE, 71: 215–218, 1930.
[3] SCIENCE, 71: 317–319, 1930.

A fact of great significance in this discussion appears to have been overlooked, that this seemingly great overmultiplication of generic names may be of a transient nature, for in many groups of animals our knowledge is still so meager that no one can predict what the final groupings may be when the structure of all species is known. Dr. H. B. Baker, in his study of the minute land snails of America, has pointed out this aspect of the case, and states that until all members of the larger groups have been studied, the different divisions must be treated as genera, which may be reduced to subgenera in the light of later study. This is equally true of the fresh-water pulmonates, in which group anatomical characteristics of great significance are being found, and the newer groupings must be kept separate as genera until more of the species have been investigated. To include many of these as subgenera would be a contravention of the facts. I can not see how we are to avoid this multiplication of genera if we are to make substantial progress in our interpretation of invertebrate life. No difficulty is encountered in using the newer classifications in teaching students who have not already absorbed the older view-points. The greatest difficulty appears to be among the workers who have for years used the older forms of classification and who find it difficult to adjust themselves to the newer view-point.

The multiplication of names is not alone confined to genera. Old species, found by careful study to be composites, are being split into two or more species. The study of environmental influences is adding to the number of subspecific names. The latter feature, carried to its logical conclusion in a recent work on fresh-water mollusks,[4] has called forth the same sort of criticism as that for the division of genera.[5]

What constitutes a species is governed so largely by personal opinion that no two authorities are likely to agree on the subject. The writer has made it a rule to consider a group of individuals which are separated from all other groups by some definite combination of characteristics, without intergrading, as species; those that show intergradations as varieties. Geographic races or varieties are for the most part generally accepted without question and need not be discussed. But when an attempt is made to interpret the action of the environment on species, and names are given to these ecological forms, objection is at once made on the ground that they are trivial and should not receive distinct names, but be designated by locality. Such a procedure is obviously impossible for the reason that two or more of these variations may occur in the same region and the reader of a communication would not know which form was referred to.

For the study of animals from the ecological and distributional standpoint these variations resulting from environmental changes must receive names to be used. In many species of fresh-water mollusks, one form may be quite uniform in shape when inhabiting the river systems of the southern and central parts of the United States, and yet show quite distinct changes in form when inhabiting the lake regions of Wisconsin, Michigan and other northern states. Even closely adjoining lakes may contain different varieties or a single lake may contain two of these varieties. Many of these have been caused by isolation in the same manner that land forms have evolved when isolated on island habitats in the ocean. For the purpose of adequate interpretation of these ecological conditions the varieties must receive names even though not all the variations are of equal value. A quadrinomial system might help in some instances, but it is not necessary. Ortmann some years ago propounded a law of river development for the naiades, based on the variation in form of the shell from the headwaters of a river to its lower, larger portion. This law was applied by the writer to the river fauna of Wisconsin and Illinois and found to hold good for nearly all species of naiades. Now to study intelligently these variations coincident with size of a stream it is necessary to have definite trinomial designations for the chief variations which may be characteristic of certain portions of the river, even though these variations are connected by intermediate forms (if they were not so connected they would constitute species).

It appears difficult for many students of nature to realize that evolution is still in progress. Species, while normally reasonably fixed for a limited period, may undergo sudden and marked change when subjected to changes of environment, even when such a simple thing as a log dam is placed across a river, converting it into a pond or lake. The log dam is quite as effective as a glacial dam across a stream which forms a glacial lake, and we have abundant evidence that changes following the damming of streams in glacial times have been followed by the most diverse changes in species, especially in the glaciated areas of Wisconsin and Michigan. There is no such thing in an organic species as the stability that we find in a "title deed," nor can a species remain as fixed as "an authoritative pronouncement from the bench" (which, by the way, may be overruled by a higher court). All animal life is subject to change as soon as the normal conditions of the environment change, and there is evidence that this change may not always be a matter of long years but may take

[4] Baker, "The Fresh-water Mollusca of Wisconsin," Bull. 70, Wis. Geol. Nat. Hist. Survey, 1928.

[5] Goodrich, *Nautilus*, 42: 114–118, 1929.

place in the space of five or ten years. This statement is abundantly supported by experimental evidence. The necessity for giving names to these incipient species is, therefore, obvious.

Taxonomy is but a tool which is used for the interpretation of life processes, and yet its value is beyond question and can not be denied by any one. It is the foundation upon which all the biological sciences rest. The alleged overmultiplication of generic and varietal names is but an attempt to inquire more closely into the true relationships of organisms. More attention should be given to this subject in university curricula in order that the student may have a just appreciation of its importance and an understanding and sympathetic attitude toward the systematist who is endeavoring to make a just and true interpretation of the relation of life to the laws through which it has come into existence. This can not be accomplished by the kind of criticism which has been in vogue, but by an increase of workers who will help to untangle much of the chaos that now surrounds the classification of many groups of animals.

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EGYPTIAN MATHEMATICS

IT may be well to make generally available information supplementing, or correcting, some matters referred to in my address on "Mathematics before the Greeks" recently published in SCIENCE,[1] since the matters in question are of somewhat general interest.

(1) Following other writers I referred to the hieroglyph for 1,000 as "a lotus flower" when further investigation would have shown that I should have said "a stem with a lotus leaf."

(2) In giving references to discussions as to "whether the Egyptian had a conception of the general fraction" I might very appropriately have given a reference to a recent discussion by Kurt Vogel who concludes[2]: "Es wird also jetzt von allen Seiten anerkannt, dass der Ägypter den klaren Begriff des allgemeinen Bruches (in dem nicht-komplexen Sinn) gehabt hat."

(3) Quoting Breasted's "Ancient Times," 1916, I noted that "the earliest dated event in history was the establishment in 4241 B. C. of the Egyptian calendar of twelve months of thirty days plus five feast days." Breasted's statement is doubtless based on Eduard Meyer's "Äegyptische Chronologie."[3] In 1917 Borchardt showed[4] that the date 4241 should be 4236 (with a possible error of two years), and up to 1925 this was the accepted date.[5] Mr. S. R. K. Glanville, of the British Museum staff, has, however, kindly pointed out to me that in a recent study of this question, Alexander Scharff[6] makes clear the possibility that 2776 instead of 4236 might in fact be the year when the Egyptian calendar was inaugurated.

(4) One of my statements concerning the Cheops pyramid needs to be revised as follows: "It is said that 100,000 workmen were kept constantly employed on this structure for thirty [not *fifty*] years, ten years of this period being used in constructing a road to the Nile, 1,017 yards [not *limestone quarry some miles*] distant." In the history of Herodotus, written in the fifth century B. C., there is a passage which informs us in this connection as follows[7]:

> Till the time of Rhampsinitus Egypt (so the priests told me) was in all ways well governed and greatly prospered, but Cheops, who was the next king, brought the people to utter misery. For first he shut up all the temples, so that none could sacrifice there; and next, he compelled all the Egyptians to work for him, appointing to some to drag stones from the quarries in the Arabian mountains to the Nile: and the stones being carried across the river in boats, others were charged to receive and drag them to the mountains called Libyan. They worked in gangs of a hundred thousand men, each gang for three months. For ten years the peoples were afflicted in making the road whereon the stones were dragged, the making of which road was to my thinking a task but a little lighter than the building of the [great] pyramid, for the road is five furlongs long and ten fathoms broad, and raised at its highest to a height of eight fathoms, and it is all of stone polished and carven with figures. The ten years aforesaid went to the making of this road and of the underground chambers on the hill whereon the pyramids stand; these the king meant to be burial-places for himself, and encompassed them with water, bringing in a channel from the Nile. The pyramid itself was twenty years in the making. Its base is square, each side eight hundred feet long, and its height is the same; the whole is of stone polished and most exactly fitted; there is no block of less than thirty feet in length.

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May 10, 1930

[1] SCIENCE, 71: 109, January 31, 1930.

[2] K. Vogel, "Die Grundlagen der ägyptischen Arithmetik in ihrem Zusammenhang mit der 2: n-Tabelle des Papyrus Rhind" (dissertation), Munich, 1929, p. 185.

[3] *Phil. u. hist. Abhandlungen d. k. preuss. Akad. d. Wiss.*, 1904, no. 1, pp. 38–44; French translation by A. Moret, Paris, 1912, pp. 48–55.

[4] L. Borchardt, "Die Annalen und die zeitliche Festlegung des alten Reiches der ägyptischen Geschichte," Berlin, 1917, p. 58.

[5] F. Meyer, "Die ältere Chronologie Babyloniens, Assyriens und Ägyptens," Stuttgart, 1925, p. 45.

[6] A. Scharff, "Grundzüge der ägyptischen Vorgeschichte," Leipzig, 1927, pp. 54–57.

[7] Herodotus with an English translation by A. D. Godley (Loeb Classical Library), London, vol. 2, 1921, pp. 424–427.

CHOMATOLOGY, SOIL SCIENCE

As one brought up in Greece and educated there as far as the baccalaureate degree, I have been especially interested in the recent discussion of the term "pedology" as applied to soil science. The contributions of Shaw,[1] Weir[2] and Peter[3] have shown quite adequately the ambiguity which now exists in the meaning of this term. If it were the most appropriate and precise term, there might be a reason for making some special effort to get it away from medicine and establish its use to designate soil science. As a matter of fact it does not really convey the meaning of soil science as that term is now used.

Whatever might be said in defense of a very general term to embrace the study of soils with no reference to their fundamental significance in plant life, the fact remains that the soil scientists are primarily those interested in plant relations, especially in agriculture. To be sure, the geologist has some interest in soil as the final degradation product of rocks, or as the progenitor of sediments. The engineer is concerned with earth as the material of embankments, dams, excavations and the like. But when we speak of soil science we but rarely and incidentally have these matters in mind. Soil science is a much more precise term than that and means the science of the soil as it relates to organisms living therein, and predominantly as it concerns agriculture. It would seem wholly desirable that any term with the λόγος ending should convey this precise shade of meaning.

Pedology, agrology and humology are all terms which do not describe what we have in mind when we say soil science. Ἔδαφος, the root for the suggested edaphology, is a collective term for ground including soil, and edaphology is fairly appropriate. Choology might serve, since its root word χοῦς means earth or soil. It is the word used in that passage in Genesis descriptive of the creation of man to denote the substance from which man was made; the King James's version translates this word as dust. The most appropriate Greek word is χῶμα, genitive χώματος. Both in classical and modern Greek this word signifies soil as the botanist and agriculturist use the term. Chomatology, therefore, is the most significant term we could adopt.

It has the advantages of being free from any entanglements and ambiguity, easy to pronounce and precise in its meaning.

C. P. SIDERIS

ASSOCIATION OF HAWAIIAN PINEAPPLE CANNERS,
UNIVERSITY OF HAWAII

SPECIAL CORRESPONDENCE

NOTES FROM THE NATIONAL MUSEUM OF CANADA

DR. R. M. ANDERSON, chief of division of biology, has received notification of his election as an honorary member of the Ornithological Society of Dresden.

Dr. M. O. Malte, chief botanist, National Herbarium, will attend the International Botanical Congress at London, in July, 1930, and also visit botanical institutions and friends in Sweden, Denmark and other countries.

Mr. P. A. Taverner, ornithologist, left the middle of May for the terminus of the Hudson Bay Railway, at Churchill, Manitoba, and will spend the summer in ornithological work on the west side of Hudson Bay with two assistants.

Dr. Morten P. Porsild, director of the Danish Arctic Station at Godhavn, Disko, Greenland, for many years, is spending several months in Ottawa, assisting in the determination of 15,000 to 20,000 sheets of botanical specimens collected by his sons, A. E. and R. T. Porsild, while on reindeer investigations for the Northwest Territories and Yukon Branch, Department of the Interior, Ottawa, in Alaska and Mackenzie district, Canada, in 1925–28, and by A. E. Porsild in James Bay and Hudson Bay in 1929. The specimens will be retained in the National Herbarium. Dr. Porsild will return to Godhavn on the S. S. *Beothic,* which will visit the Eastern Arctic on its annual patrol, sailing from North Sydney, N. S., late in July.

Mr. Hamilton M. Laing, of Comox, and Mr. Ian McTaggart-Cowan, of North Vancouver, B. C., collected small mammals and birds in the Tobacco Plains region of southeastern British Columbia in April and May for the museum. Mr. Laing began work as park naturalist in National Parks of Canada on June 1, and will be stationed at Jasper Park and Rocky Mountains Park at Banff, Alberta, for the remainder of the season. Mr. McTaggart-Cowan will continue work for the National Museum of Canada until September 30.

Mr. J. Dewey Soper, of Ottawa, who spent 1924–26 as naturalist for the museum in the Cumberland

[1] Chas. F. Shaw, Is "Pedology" Soil Science? *Jour. Amer. Soc. Agron.*, 22: 235–238, 1930.

[2] W. W. Weir, "Soil Science," SCIENCE, 71: 218, 1930.

[3] A. M. Peter, "Soil Science," SCIENCE, 71: 218, 1930.

Sound region of Baffin Island, and 1928–29 in Cape Dorset and Foxe Channel region for the Department of the Interior, will leave in July for Lake Harbour, Baffin Land, north side of Hudson Strait, where he will spend two years as investigator, North West Territories and Yukon Branch, Department of the Interior. One of the results of Mr. Soper's 1928–29 expedition was the discovery of the hitherto unknown nesting grounds of the blue goose.

CORRESPONDENT

QUOTATIONS

THE DETROIT SESSION OF THE AMERICAN MEDICAL ASSOCIATION

THE multitude of provisions for instruction and entertainment at the Detroit session was perhaps the most striking feature of the annual session of the association just held in that city. Some activity was scheduled for satisfactory use of every moment of the visitor's time, and it remained only for him to employ his time to his own best advantage. From the first two days, during which a series of extraordinary clinical lectures and talking motion pictures were available, to the last three days, in which the fifteen scientific sections provided more than three hundred manuscripts on various phases of medical progress, scientific discourse occupied the auditorium and the halls in the Masonic Temple. At the same time, the greatest number of scientific and technical exhibits ever assembled under the auspices of the association held forth in every available space on several floors in the same building. For the evening the Michigan State Medical Society provided a past-presidents' dinner for the opening night, given exclusively for the officers and the House of Delegates; the opening meeting with the presentation of emblems to past-presidents took place on Tuesday night; numerous fraternity and other social entertainments were held on Wednesday; the president's reception on Thursday, and boat rides, motor bus trips and private tours were provided by the Local Committee on Arrangements for the intervening periods, if any. Obviously, complete utilization of such provisions placed a tax on the physical endurance of the convention guest, and a course of rest and physical training in anticipation of the session was almost necessary to enable the too enthusiastic conventionist to survive successfully the session's attractions. The meetings of the House of Delegates were marked primarily by the demonstration of confidence in the work of the Board of Trustees and by special interest in the economic problems affecting the progress of medicine to-day. Thus, resolutions concerning the care of veterans' legislation, federal aid on maternal welfare, mental hygiene, and similar problems dominated the picture. It is significant that the resolution concerning aid for veterans adopted by the House of Delegates was specifically referred to by the President of the United States in his message vetoing the veterans' bill. The attendance of more than five thousand physicians in a time of financial stress indicates the manner in which the medical profession accepts the importance of this annual session. The appreciation of all of those who attended must be tendered to the Local Committee on Arrangements, which contributed freely of its funds, its time and its efforts to build the success of the meeting. The hospitality shown has established the profession of Detroit in the affections of the Fellows of the American Medical Association.—*Journal of the American Medical Association.*

SOCIETIES AND MEETINGS

THE HISTORY OF SCIENCE SOCIETY MEETING IN DURHAM, NORTH CAROLINA

THE History of Science Society met concurrently with the American Historical Association at the forty-fourth annual meeting at Durham and Chapel Hill, North Carolina, on December 30 and 31, 1929, and January 1, 1930.

This is the tenth anniversary of the History of Science group of the American Historical Association which was inaugurated in 1920 by Dr. Lynn Thorndike, of Columbia University, president of the History of Science Society. The following year a similar section was instituted by the American Association for the Advancement of Science at the Chicago meeting with the late Dr. William A. Locy as chairman of the committee, later vice-president of Section L.

The interest in the history of science movement has grown so steadily ever since that finally both groups were combined to form the History of Science Society, under the direction of Dr. David Eugene Smith at Columbia University in 1924. The society now enjoys its sixth anniversary, and a membership close to seven hundred, consisting of many of the most distinguished scholars and scientists of the world.

The short program presented at Durham on January 1 was entirely devoted to the history of early

American scientific development. Following are the titles of the papers. This meeting was presided over by Dr. Thorndike, and the discussion was led by Dr. L. C. Karpinski followed by Dr. W. H. Welch, Dr. Joseph Mayer, Dr. Victor H. Paltsits and others. Discussion proved of great value and importance.

"Influence of the Mathematics of the French Revolution on Mathematics in American Colleges," by Dr. Lao G. Simons, Hunter College.

"Popularization of Science in the American Revolutionary Era," by Dr. Evarts B. Greene, Columbia University.

"A Century of American Geodesy," by Dr. Florian Cajori, University of California.

"Medical Practice in the Old South," by Dr. Richard H. Shryock, Duke University.

Dr. Shryock's paper was given at 12:30 at the complimentary luncheon (by Duke University) conference on the history of science. Dr. H. W. Tyler, of the Massachusetts Institute of Technology, presided.

Following is an extract of the council record.

The Council of the History of Science Society met at the Hope Valley Country Club, Durham, North Carolina, on December 30, 1929, at 4:15 P. M., with President Lynn Thorndike in the chair. There were present the president, Professors Crew, Cajori, Karpinski, Shryock, Simons, Tyler, Welch and Secretaries Brasch and Mayer. Dr. d'Irsay was also present as a guest. The minutes of the last meeting were read and approved.

The following new officers and council members were elected: *President,* Dr. Henry Crew; *vice-presidents,* Dr. William H. Welch, Dr. Berthold Laufer; *members of the council to serve until December, 1932:* Dr. Victor Robinson, Dr. Henry G. Gale, Dr. Richard H. Shryock, Mr. George E. Roberts, Dr. Alfred C. Lane.

The report of the treasurer and corresponding secretary was read and approved. Mr. Brasch gave an account of his efforts to secure a translation of the work of Copernicus and the nominal expenses involved. The report was accepted and placed on file. It was voted to extend the thanks of the council to the Carnegie Corporation of New York for the appropriation of $7,500 to establish a revolving fund for publications; to authorize the incoming president to appoint a committee of three to be known as the revolving book fund committee to have general responsibility for the administration of the fund, major matters of policy to be passed upon by the council. It was further voted that, if a translation of the Copernicus manuscript entitled "De Revolutionibus, etc.," is published under the auspices of the History of Science Society, it should be a complete rendition of the original.

In the absence of the editor of *Isis,* the president read two communications from him, after which the following actions were taken: Voted that the council authorize the appointment by the president of an executive committee of five members, the incoming president to be the chairman for the year 1930 and to select the other four members;[1] that the executive committee take up with Dr. Sarton the question of drafting an agreement between him and the History of Science Society regarding the conduct of *Isis.*

President Thorndike presented an interesting account of his contact with the Comité Internationale d'Histoire des Sciences in London, after which it was voted to give consent to the use of the name of the History of Science Society in connection with the International Congress of the History of Science and Technology to be held in London in July, 1931, without involving the History of Science Society in any expense.

Dr. Mayer reported informally regarding the work of the endowment committee and read extracts of letters commenting on the tentative draft of the endowment project previously circulated to the council. The report of progress was accepted and placed on file.

Dr. Thorndike was elected delegate to the American Council of Learned Societies for term of four years.

Mr. Brasch was reelected treasurer and corresponding secretary for 1930.

Dr. Mayer was reelected recording secretary for 1930.

It was voted that the executive committee be asked to take up the question of a redistribution of the functions of the treasurer and the secretaries and report back to the council.

The meeting was adjourned at 6:30 P. M.

After the large amount of important matters of business and election of officers, the members of the council enjoyed a unique and fine Southern dinner prepared under the direction of Dr. Shryock. Following this, the members of the council were taken back to hear President James H. Robinson's address.

The History of Science Society will meet with the American Association for the Advancement of Science in Cleveland in 1930.

FREDERICK E. BRASCH,
Corresponding Secretary
JOSEPH MAYER,
Recording Secretary

SCIENTIFIC APPARATUS AND LABORATORY METHODS

A MICROSCOPE-CENTRIFUGE

THE centrifuge has been used in experimental study of living cells for several types of investigation. First, to determine relative specific gravity and total volume of granules (which are stratified under centrifugal force) present in living cells. Second, to

[1] At a later date the president reported the following appointments to the executive committee: R. C. Archibald, F. Cajori, H. G. Gale, H. W. Tyler, H. Crew.

observe the behavior of mitotic figures and other structures under centrifugal force, experiments which give a clue to the nature of the structure, that is, whether solid and resistant to deformation or merely the configuration of particles in an electrical field. Third, to measure the viscosity of the protoplasm, by applying Stoke's law to the rate of movement of granules under the centrifugal force. The previous procedure has been to centrifuge the cell in capillary tubes, remove it from the tube and observe it under a microscope to determine what happens.

It would obviously be far better to observe the effect of centrifugal force while the force was acting. An instrument for this purpose could be constructed, in theory, making use of several different principles. Our communication describes a practical means of attaining this end. We can obtain a magnified *image* of cells making 2,000 to 3,000 R.P.M. at a distance of 10 cm from the centrifuge axis.

As shown in the accompanying diagram, Fig. 1,

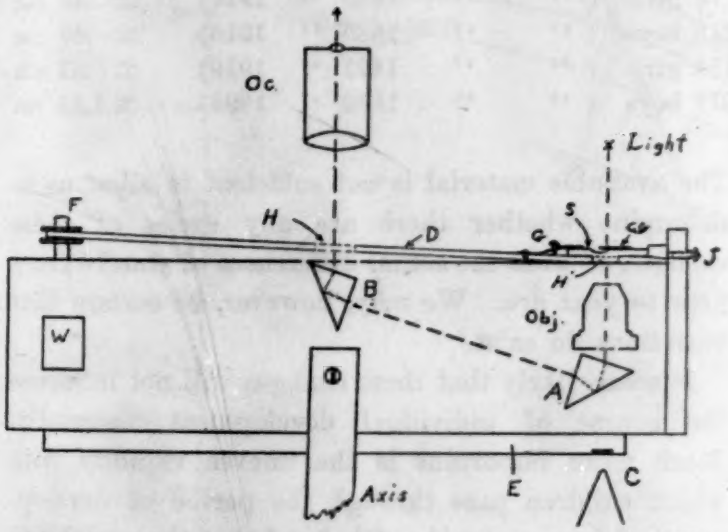

FIG. 1. Optical system of microscope-centrifuge. Explanation in text.

a microscope objective (*obj.*) is built into one end of a bar of metal which is mounted as a head on the centrifuge axis. The objective is purposely reversed from the ordinary position on a microscope so that the light (*L*), the focusing screw (*F*) and the slide containing living cells (*S*) will be easily accessible on the top of the centrifuge. After passing the objective, the light is carried by two total reflecting prisms, *A* and *B*, to the axis of the centrifuge and then vertically upward. The eyepiece (*Oc.*) is stationary and mounted permanently above the axis of the centrifuge. The counter weight (*W*) is used for balancing.

A slide to hold cells can easily be made from a hollow depression microscope slide by cementing a cover slip (*C.G.*) over one half of the depression. There is thus formed a niche between cover slip and surface of slide in which cells are thrown by the centrifugal force. The slide, cut to proper size, is laid on a flat strip of metal, *D*, with holes at *H* and *H'* for passage of light, and held down by the clamp *G*. Its position in the direction of the centrifugal force can be adjusted by the screw *J*. The slide can be focused by moving the whole bar, *D*, up and down on the focus screw *F*, and additional focusing during centrifuging is obtained by changing the vertical position of the ocular. If the cells are illuminated continuously, the image in the eyepiece, while the centrifuge is running, would be whirling in a small circle. However, if we illuminate the cells for a few microseconds every time they reach a position in the revolution under the light, the appearance will be that of a succession of images, a moving picture. The cells will appear stationary; the granules within will be seen to move under the centrifugal force.

The illumination is a 2,000 volt condenser discharge in mercury vapor at atmospheric pressure or above. The lamps can easily be made by sealing a tungsten wire into one end of a pyrex capillary tube which is partly filled with mercury. A portion of the tube near the other end of the capillary is enlarged to a small bulb and an iron wire pushed down the capillary to the proper distance from the tungsten to form the other electrode for the condenser discharge. This iron electrode is then sealed in with deKhotinsky cement, leaving the bulb filled with air. A heating coil around the capillary, not shown in the illustration, protected from air currents by an enclosing pyrex tube, boils the mercury in the capillary, forming mercury vapor through which the discharge takes place. A reservoir condenser is kept continually charged to 2,000 volts from a transformer and rectifying tube. The discharging condenser, of lower capacity, is in parallel with the reservoir condenser through a high resistance. With each revolution of the centrifuge the contact point *C* on the bakelite disk (*E*) discharges the 2,000 volts through the mercury lamp, and during the remainder of the revolution the condenser is again charged through the

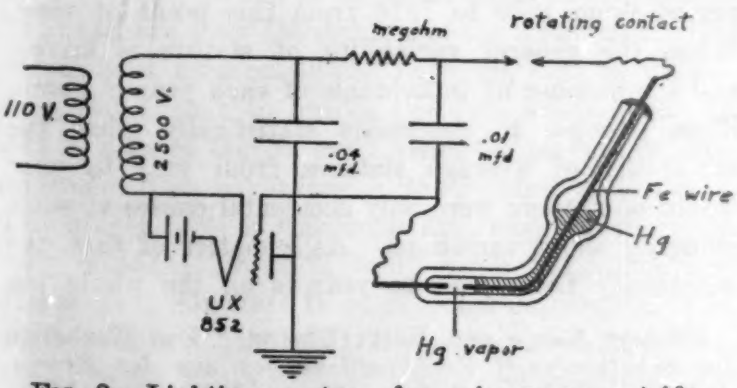

FIG. 2. Lighting system for microscope-centrifuge. Explanation in text.

high resistance and is ready for another discharge. The wiring diagram and lamp are shown in Fig. 2.

The image is remarkably steady with high power objectives (×62) and we have obtained photomicrographs with the microscope-centrifuge, using a ×62 objective, of bacteria and chromosomes in dividing cells which can hardly be distinguished from those taken when the cells are at rest.

PRINCETON UNIVERSITY
LOOMIS LABORATORY,
TUXEDO PARK, N. Y.

E. NEWTON HARVEY
ALFRED L. LOOMIS

SPECIAL ARTICLES

OBSERVATIONS ON THE GROWTH OF CHILDREN

A CLEAR understanding of the statistics of growth can not be obtained through a study of single measurements taken on masses of children of the same age—by the so-called generalizing method, but requires the study of individual amounts of growth. If the generalized series is considered as representative of individual growth, two assumptions are made; the one that the traits of the population represented by children of different ages remain the same from year to year; the other that all children pass through the period of growth at the same rate. Neither of these assumptions is admissible. Observations in Europe show clearly that the size of the body is undergoing secular changes. From the middle of the past century until the beginning of the present century the average stature in Europe increased in every single country. Recent observations also show that the stature of growing children, comparing the years 1880 and 1921, has considerably increased.[1] Besides these increments, which are probably due to better control of diseases of childhood, perhaps also to general improvement in hygienic conditions, there are minor changes which occur from year to year. I have studied the statures of individuals born during the period from 1870 to 1916 from this point of view. When the general variability of stature is known and the number of individuals of each year is given, it is possible to determine statistically what the variability of average statures from year to year would be if there were only accidental causes at work bringing about variations. As a matter of fact, the variability from year to year is on the whole too large and the calculation shows that a standard variation of about 0.5 cm or more must be assumed for irregular variations of stature. This variability of stature, so far as it is not due to chance, has been calculated from observations of children born in various years. It will be understood that the numbers of cases are observations repeated annually, many taken on the same individuals, not all distinct individuals.

Hebrew Orphan Asylum, N. Y.	2,275 boys	(born between	1894	and	1916)	$\Sigma = \pm$ .51 cm
" " " "	2,178 girls	("	" 1889	"	1916)	$\pm$ .45 cm
Ethical Culture School, N. Y.	1,248 boys	("	" 1889	"	1916)	$\pm$ .49 cm
" " " "	1,154 girls	("	" 1891	"	1915)	$\pm$ .53 cm
Newark Academy	3,817 boys	("	" 1870	"	1898)	$\pm$ 1.13 cm

The available material is not sufficient to allow us to determine whether there are any cycles of these changes, or what the actual differences of stature from year to year are. We may, however, be certain that variations do exist.

It seems likely that these changes will not influence the course of individual development materially. Much more important is the uneven rapidity with which children pass through the period of development. I have pointed out before[2] that the variability of physiological age increases very rapidly during life. At the time of birth it may be measured by a few days. That is to say, the total period of gestation differs only by a small number of days. The eruption of the first teeth differs by several weeks. The time of eruption of later teeth is even more variable. The time of reaching maturity varies by more than a year and that of senescence by seven or eight years. While it is not admissible to assume that the variability of any one of these phenomena indicates a general variability in physiological age of the whole organism, all the data combined show that the variability of physiological status increases rapidly during the course of life.

The curve of growth for the body as a whole, as

[1] Robert Rössle and Herta Böning, "Das Wachstum der Schulkinder," *Veröffentlichungen aus der Kriegs- und Konstitutionspathologie*, Vierter Band, Heft 1, pp. 24 et seq.

[2] Franz Boas and Clark Wissler, "Statistics of Growth" (Report of the U. S. Commissioner of Education for 1904), Washington, 1905, p. 40.

well as for its parts, is characterized by a gradual decrease in the rate of growth during childhood, followed by a period of increased rapidity of growth during adolescence and final completion of growth when maturity is reached. I demonstrated a number of years ago that, admitting the variability of physiological development and its determinant influence upon growth rates, the actual individual growth rate must show a much more decided decline during childhood and a much more decided increase during adolescence, and that at the same time the period of increased rapidity of growth during adolescence must be much shorter than would appear from the generalized curve.[3]

A number of years ago I obtained, through the courtesy of Dr. Wilson Farrand, continuous measurements of boys in the Newark Academy, a rather uniform social group of almost exclusively northwest European descent. These data were calculated according to my suggestion by the method of correlation by Dr. Clark Wissler.[4] It appeared later that this method is unsatisfactory on account of the asymmetry of the growth curves and because the fundamental questions are not well expressed by the coefficient of correlation. Furthermore, the data did not continue until the adult stage was reached. For this reason I have treated the same material according to another method. I also obtained with the kindly help of Dr. Farrand the adult statures of a fairly large number of the former students of the academy.

In Fig. 1 are given the total increments of stature up to adult stature for each year, beginning with 11 years. The ordinates show the total amount of growth from 11, 12 . . . up to 17 years on to adult stature. The abscissae show the statures at the initial age. The curves have been calculated from the data as parabolas, which seem to render the data adequately. It will be noticed that in early years the maximum total increment does not belong to the shortest individuals. The curves have a maximum and later on drop off very rapidly. From 11 to 15 years the curves are decreasingly concave; from 16 years on, convex. On the curves are indicated the average statures for initial years, the points at which the increment up to adult stature is a maximum and the point for

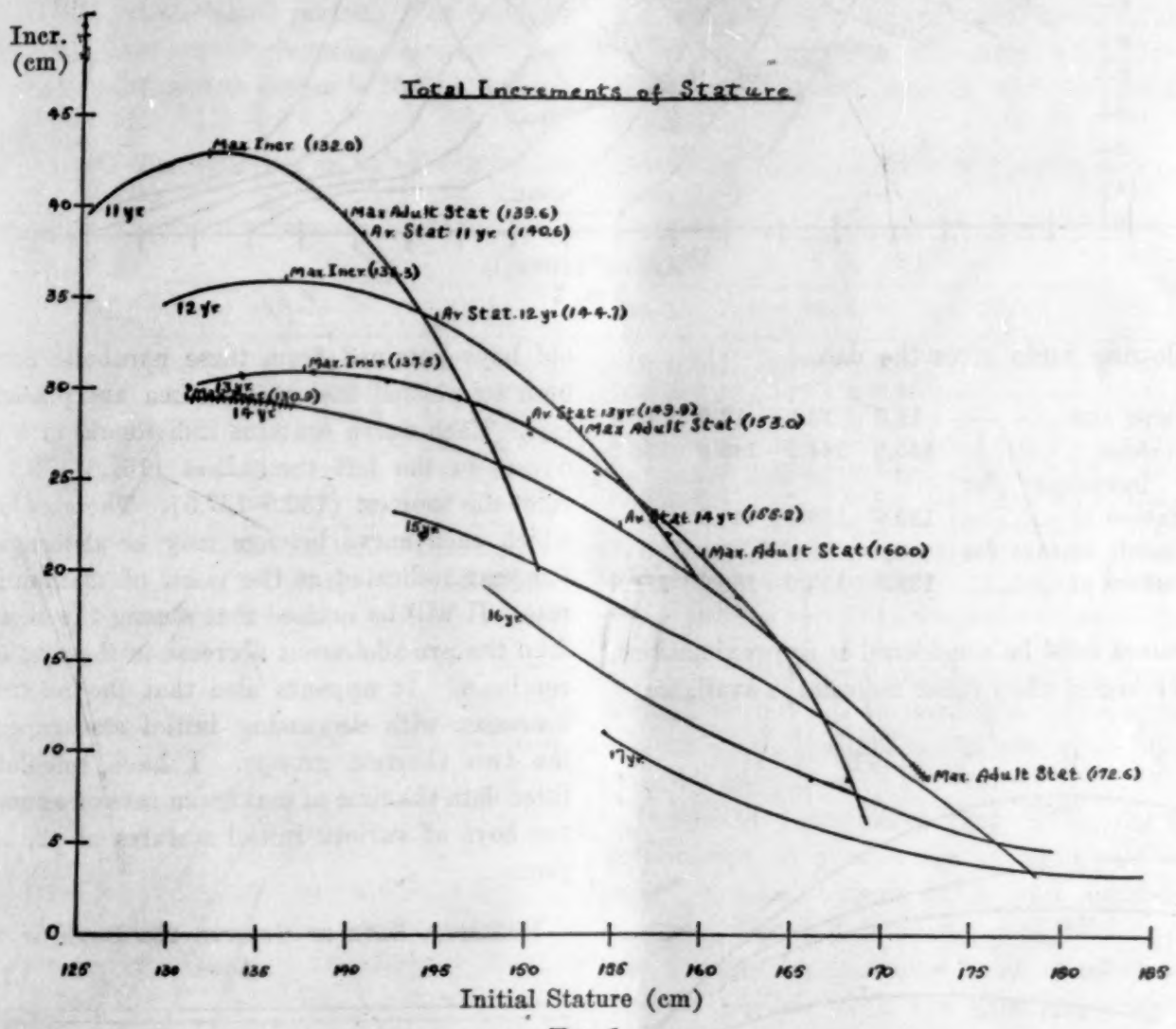

FIG. 1

[3] *Ibid.*, pp. 42, 48.

[4] *Ibid.*, pp. 43–45; *Amer. Anthropol.*, N. S., 5: 81–88, 1903.

which the adult stature is a maximum. For 11 years the maximum increment is found for children 132 cm tall, the average stature is 140.6 cm, the maximum adult stature belongs to those who have at 11 the stature 139.6 cm.

The general curve of growth of children 12 years old of various initial statures is illustrated in Fig. 2. In this figure the abscissae represent statures at 12 years, the ordinates the growth up to 13, 14, etc., years. In Fig. 3 the annual increments for 14 year

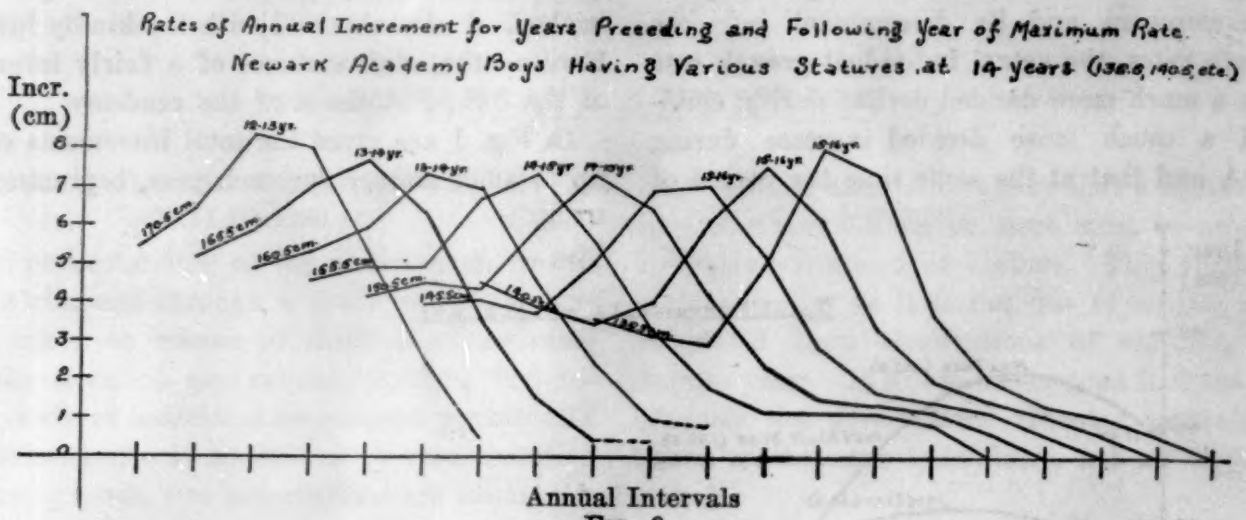

FIG. 3

The following table gives the data.

FOR BOYS OF AGE	11.5	12.5	13.5	14.5
Average stature	140.5	144.7	149.9	155.2
Maximum increment for initial stature at	132.0	136.3	137.5	——
Maximum adult stature for initial stature at	139.6	153.0	160.0	172.6

These values must be considered as approximations, subject to revision when fuller material is available.

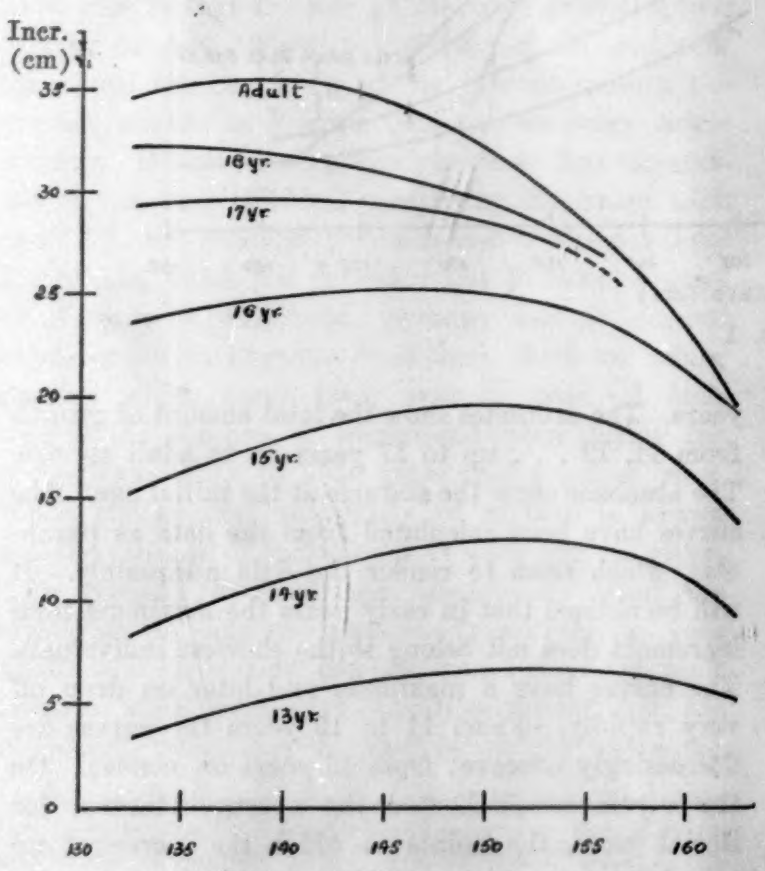

FIG. 2

old boys obtained from these parabolic curves have been so plotted that the maxima are placed side by side. Each curve contains individuals in a group of 5 cm—to the left the tallest (167.5–172.5), to the right the shortest (132.5–137.5). The absolute age to which each curve belongs may be determined from the year indicated at the point of maximum annual rate. It will be noticed that among the shortest children the pre-adolescent decrease in the rate of growth continues. It appears also that the maximum rate decreases with decreasing initial stature except for the two shortest groups. I have calculated from these data the time of maximum rate of annual growth for boys of various initial statures at 12, 13 and 14 years.

MAXIMUM RATE OF GROWTH FOR BOYS OF VARIOUS AGES

	Years	Years	Years
Statures	12.5	13.5	14.5
	Maximum Rate at		
132.5	15.8	15.3	16.7
137.5	15.2	14.8	16.0
142.5	14.7	14.7	15.5
147.5	14.3	13.7	14.8
152.5	(12.5)	13.7	14.3
157.5	—	13.2	14.0
162.5	—	11.6	13.4
167.5	—	—	13.1

For the average statures this would give[5]:

[5] The differences between the following averages and those given before are due to the inclusion of additional individuals in the present series.

Age years	Average stature	Age of maximum rate
12.5	145.2	14.5
13.5	149.9	13.7
14.5	155.5	14.1,

approximately the same age. The table shows clearly the acceleration of development with increasing initial stature.

These phenomena may also be approached by a study of the growth of individuals who have their maximum growth at the same period. For the boys of the Newark Academy the average age at which the maximum rate of growth occurs is 14.5 ± .9 years.

Fig. 4 indicates the course of actual growth of five groups. The first has its maximum rate of growth between 12 and 13; the second from 13 to 14, and so on up to those in which the maximum growth rate is between 16 and 17 years. It will be seen that the statures of those who have the earliest maximum growth are considerably larger than those of others who have the maximum growth at a later time. The differences naturally increase first, but decrease again considerably later on. The differences among the adults of these various groups are so small and so irregular that, considering the small number of cases that are available, we may well assume that there is no relation between the time when the greatest rapidity of growth sets in and the stature finally

STATURES AND VARIABILITIES OF NEWARK BOYS WHO HAVE THEIR MAXIMUM RATE OF GROWTH IN VARIOUS YEARS (IN CM)

Age	Maximum rate at 12–13	13–14	14–15	15–16	16–17	Total
11	142.2 ± 5.1	140.5 ± 5.4	139.5 ± 5.4	135.8 ± 5.4	———	139.7 ± 5.7
12	148.7 ± 5.5	145.5 ± 5.3	143.9 ± 6.3	140.8 ± 6.4	———	144.3 ± 6.3
13	158.7 ± *6.5*	151.8 ± 5.2	148.6 ± 6.7	144.7 ± 6.3	———	149.4 ± 7.2
14	165.7 ± 6.4	161.1 ± 5.5	155.1 ± 6.9	150.2 ± 6.8	145.7 ± 7.3	155.7 ± 8.3
15	170.2 ± 5.9	167.2 ± 5.5	164.1 ± *7.0*	156.3 ± 7.2	150.5 ± 7.4	162.8 ± *8.4*
16	———	170.9 ± 5.7	169.9 ± 6.9	165.1 ± *7.3*	157.2 ± 7.5	168.1 ± 7.7
17	———	172.8 ± 5.0	172.6 ± 6.8	170.0 ± 7.0	165.9 ± *8.1*	171.2 ± 7.0
18	———	———	174.5 ± 6.8	173.3 ± 7.6	169.0 ± 7.9	173.6 ± 6.7
Adult	(175.7)	174.2 ± 4.6	176.7 ± 5.6	178.9 ± 6.3	(175.4)	176.1 ± 5.9

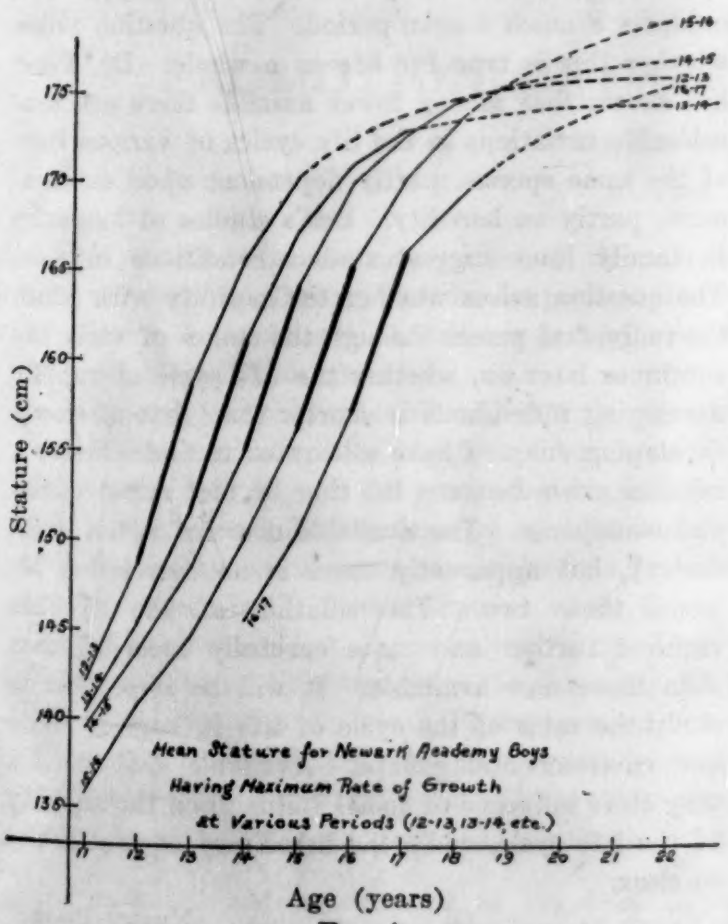

FIG. 4

attained. This conclusion is subject to revision when more material will be available. The averages and various totals for this series are given in the table given above.

It will be remembered that during the period of acceleration of growth the variability of the whole series increases considerably and decreases again later on. I have pointed out at a previous time[6] that this can best be explained as an effect of the difference in period when the greatest acceleration of growth occurs. It is interesting to note that the variabilities of the five curves, just shown, still indicate an increase in variability at the time of most rapid growth. The amount of this variability is considerably less than in the entire series. For boys who have their maximum rate of growth between 13 and 14 years there is practically no change in the variability from 11 years to 17 years. It is quite striking that the variabilities are the greater the later the period of most rapid growth. In our present series the variability of the adult is also the greater the later the period of most rapid growth. It remains to be seen whether this is a significant differ-

[6] "Statistics of Growth," p. 25 et seq.

ence. If it is, we might conclude that environmental conditions have the more effect the longer they exert their influence upon the body.

An analysis of the data also shows that the earlier the most rapid growth occurs, the more intensive is the total amount of increment during the period around the maximum rate. This is indicated in the following table.

Increments of Stature of Newark Boys During Intervals Around Year of Maximum Rate of Growth

	Intervals in Years			
Maximum rate	−0.5 to +0.5	−1.5 to +1.5	−2.5 to +2.5	−3.5 to +3.5
Years	cm	cm	cm	cm
12–13	10.0	23.2	32.2	38.0
13–14	9.2	21.7	30.1	37.0
14–15	9.1	21.5	29.3	35.4
15–16	8.8	20.4	27.8	33.3
16–17	8.7	20.0	27.9	34.5

The intensity of growth during the period of adolescence is the less the later adolescence begins.

The distribution of individual increments in each of these groups is not by any means uniform. To a certain extent this is due to the grouping together of an interval of a whole year, for during this period considerable changes in rate of growth occur. Furthermore, the differences between measurements taken at annual intervals from which growth rates are obtained are always inaccurate, so that their variabilities contain a rather large element due to observational errors. More important, however, are the individual differences in periods of acceleration and of total growth. This is indicated in the following table.

Percentage of Those who Grow Less than 1 cm from Various Ages on, According to the Period of Maximum Rate of Growth

Maximum rate	Age after which growth is less than 1 cm			
	16 yrs.	17 yrs.	18 yrs.	19 yrs. or more
	Per cent.	Per cent.	Per cent.	Per cent.
13–14	5	25	28	42
14–15	1	5	19	75
15–16	0	0	9	91

The distribution of amounts of annual increments for the group with maximum growth between 14 and 15 years is shown in the following table.

Individual Increments for Newark Boys with Maximum Rate of Growth between 14 and 15 Years

cm	10–11	11–12	12–13	13–14	14–15	15–16	16–17	17–18
0– 0.9	—	—	1	1	—	1	5	11
1– 1.9	—	1	—	1	—	2	11	14
2– 2.9	—	1	1	—	—	4	25	15
3– 3.9	4	12	17	2	—	6	21	4
4– 4.9	8	27	29	13	—	18	14	—
5– 5.9	7	14	31	22	1	28	2	—
6– 6.9	1	3	11	36	2	34	2	—
7– 7.9	—	—	2	29	15	17	1	—
8– 8.9	—	—	1	16	42	13	—	—
9– 9.9	—	—	—	5	39	1	—	—
10–10.9	—	—	—	1	18	—	—	—
11–11.9	—	—	—	1	7	—	—	—
12–12.9	—	—	—	—	4	—	—	—
13–13.9	—	—	—	—	1	—	—	—

It will be seen that at the time of maximum rate of growth the distribution of increments is quite symmetrical, while at earlier and particularly later periods it becomes very asymmetrical on account of the varying length of the growth period.

These observations may be expressed in a general statement. The life cycle of children between the ages of 10 and 20 years develops with varying rapidity. In some individuals the whole physiological development so far as it is expressed by stature proceeds rapidly and energetically and the whole developmental period is short; in others it is sluggish and occupies a much longer period. The question arises whether this is true for life as a whole. Dr. Pearl has shown that among lower animals there are considerable variations in the life cycles of various lines of the same species, partly dependent upon environment, partly on heredity. Bell's studies of longevity in family lines suggest similar conditions in man. The question arises whether the rapidity with which the individual passes through the stages of early life continues later on, whether the life cycle of rapidly developing individuals is shorter than that of slowly developing ones. I have attempted to find whether a relation exists between the time of first menstruation and menopause. The available material is not satisfactory, but apparently there is no correlation between these two. The solution of the problem requires further and more carefully recorded data than those now available. It will be important to study the rates of the cycle of life in various racial and environmental groups. Available data show a very clear influence of social status upon the rapidity of the life cycle, while the hereditary control is not so clear.

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